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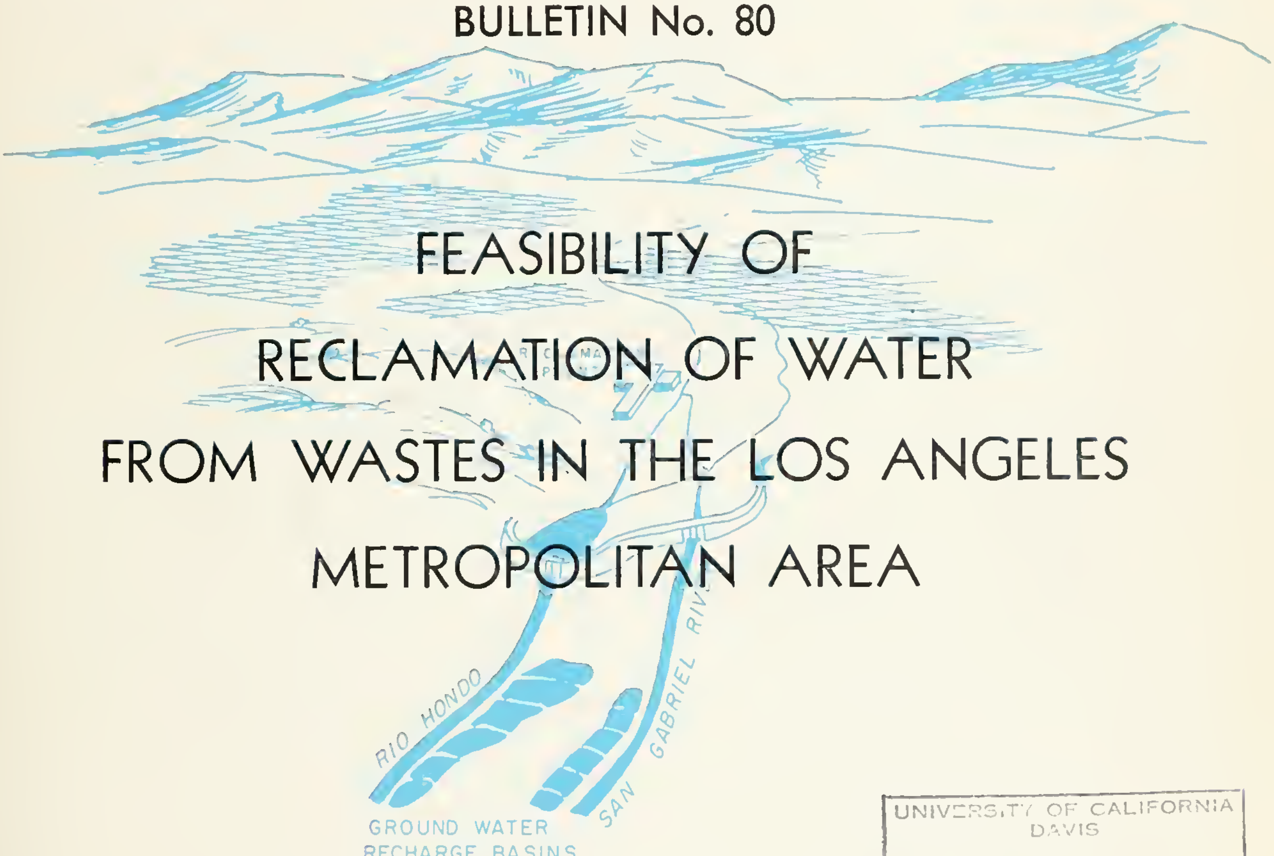

FEASIBILITY OF RECLAMATION OF WATER FROM WASTES IN THE LOS ANGELES METROPOLITAN AREA

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Governor
State of California

WILLIAM E. WARNE
Administrator
The Resources Agency of California
and Director
Department of Water Resources

LOS ANGELES METROPOLITAN AREA

Courtesy of Fairchild Aero Surveys, Inc.

The Los Angeles Metropolitan Area has experienced phenomenal growth . . .

State of California

THE RESOURCES AGENCY OF CALIFORNIA

Department of Water Resources

BULLETIN No. 80

FEASIBILITY OF RECLAMATION OF WATER FROM WASTES IN THE LOS ANGELES METROPOLITAN AREA

DECEMBER 1961

EDMUND G. BROWN
Governor
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THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
1120 N STREET, SACRAMENTO

January 12, 1962

Honorable Edmund G. Brown, Governor, and
Members of the Legislature of the
State of California

Gentlemen:

I have the honor to transmit herewith Bulletin No. 80 entitled, "Feasibility of Reclamation of Water from Wastes in the Los Angeles Metropolitan Area". The investigation described in this report was conducted in accordance with Section 230 of the Water Code, which provides that the reclamation of water from sewage and industrial waste shall be investigated by the Department of Water Resources.

Fundamental ideas on waste water reclamation and statistics on potentially reclaimable ocean discharges of sewage and industrial waste in the Los Angeles Metropolitan Area were presented in three progress reports published in December 1952, June 1954, and January 1958.

This report concludes that about 40 percent of the sewage now wasted to the ocean from the Los Angeles area could be economically reclaimed for beneficial purposes. The remainder of the sewage is of such poor mineral quality that economic reclamation is not feasible. Planned reclamation of water in the Los Angeles Metropolitan Area can be accomplished at costs comparable to, or less than, the costs of present and future supplies imported to the area. The use of water so reclaimed for ground water recharge and certain industrial purposes would conserve high quality local and imported water for domestic supplies.

Sincerely yours,

William E. Warne

Director

ACKNOWLEDGMENT

The detailed sampling and flow measurement programs, which provided a major portion of the basic data utilized in this report, were made possible only by the extensive cooperation of the City of Los Angeles, County Sanitation Districts of Los Angeles County, and County Sanitation Districts of Orange County. Many man-hours were expended by each of these agencies during the sampling of their respective sewerage systems. These agencies also contributed much basic data from their files and provided counsel and advice throughout the course of the investigation. These contributions are gratefully acknowledged.

The contributions of many other public agencies, private organizations, and individuals in providing data are acknowledged with appreciation. Particular recognition is due to the following:

State Department of Public Health, Bureau of Sanitary Engineering

Los Angeles County Engineer

Los Angeles County Flood Control District

Los Angeles Regional Water Pollution Control Board

Santa Ana Regional Water Pollution Control Board

Mr. C. R. Browning, Consulting Engineer for Talbert Water District

Many of the analyses reported herein were made by Pacific Chemical Consultants and by the State Department of Public Health, Division of Laboratories, under contractual agreement with the Division of Water Resources.

STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

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WILLIAM E. WARNE, Administrator, The Resources Agency of California
and Director, Department of Water Resources
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William M. Carah
Executive Secretary

George B. Gleason
Principal Engineer

Hyperion Treatment Plant

"The City of Los Angeles operates two main sewerage systems. The larger system drains ... to Hyperion Treatment Plant ...."

CHAPTER I. INTRODUCTION

Continuing development of the Los Angeles Metropolitan Area has created a demand for water which for many years has exceeded the safe yield from local water supplies. Because local water supplies are primarily derived from ground water, most of the ground water basins in the area are overdrawn and the ground water table has been lowered to the extent that sea water is intruding certain of the major aquifers and threatening others. The importance of these ground water supplies may be realized when one considers that over 50 percent of the total water supply of the Los Angeles Metropolitan Area is obtained from ground water.

Two major projects to import additional water to the Los Angeles Metropolitan Area to augment the natural supply have been completed. These projects are the Los Angeles Aqueduct, constructed by the City of Los Angeles to import water from the Mono and Owens Basins, and the Colorado River Aqueduct, constructed by The Metropolitan Water District of Southern California to import water from the Colorado River. During fiscal year 1959-60 these imported water supplies provided 48 percent of the water requirements of the City of Los Angeles and The Metropolitan Water District within the Los Angeles Metropolitan Area.

During the past 10 years the State Department of Water Resources has completed the formulation of the California Water Plan and its first unit, the Feather River and Delta Diversion Projects. The California Legislature has adopted the California Water Plan as the master plan for continuing development and has authorized the Feather River and Delta Diversion Projects for construction, with some work on the projects already in progress. This planning envisions importing to the Southern California

Area large quantities of surplus Northern California water to meet the anticipated continuing growth of water demands in that area.

During the course of this recent planning, the question frequently arose regarding the degree to which increasing water requirements of the Los Angeles Metropolitan Area could be supplied by reclamation and re-use of waste waters presently being discharged to the ocean through outfall sewers. Therefore, the department has conducted this investigation for the purpose of identifying locations in the Los Angeles Metropolitan Area where waste water supplies are and will be available and the quantity and quality of these supplies. Finally, studies were conducted of the engineering feasibility of plans for reclamation of these waste waters and preliminary estimates were made of the capital and annual costs of the reclamation projects studied to evaluate unit water costs for comparison with costs of water from other sources.

The major portion of the data for this investigation was compiled during 1955 and 1956. During the interval 1956 to 1960 a number of changes and additions to sewerage systems were completed. For this reason spot checks were made in 1960 to ascertain whether any radical changes in quality or quantity of waste water flows had occurred which might bear on the practicability of the reclamation plans discussed herein. Results of these spot checks are reported where appropriate in this report. It appears that the plans discussed herein are generally applicable to current waste disposal conditions, subject only to minor modifications of design flows.

This report contains a description of the methods and procedures followed in the investigation and of the findings of the studies of waste water reclamation plans for the Los Angeles Metropolitan Area. The material presented is intended for the use of responsible local agencies or individual concerns who may find an application to their specific water operations in one of the plans presented or some modification thereof.

Authorization

Investigations of the reclamation of water from sewage and industrial waste are authorized by Section 230 of the California State Water Code, quoted as follows:

> "230. The department, either independently or in cooperation with any person or any county, State, Federal or other agency, to the extent funds are allocated therefor, shall conduct surveys and investigations relating to the reclamation of water from sewage or industrial waste for beneficial purposes, including but not limited to the determination of quantities of such water presently wasted, and possibilities of use of such water for recharge of underground storage or for agricultural or industrial uses...."

This investigation was conducted and report prepared pursuant to the foregoing authorization.

Related Investigations and Reports

Many reports pertaining to the subject of sewage reclamation have been published. In addition, considerable data were obtained in unpublished form from the City of Los Angeles, the County Sanitation Districts of Los Angeles County and of Orange County, the Los Angeles County Flood Control District, and the Los Angeles and the Santa Ana Regional Water Pollution Control Boards. Published reports of major investigations conducted within the Los Angeles Metropolitan Area are:

Arnold, C. E., Hedger, H. E., and Rawn, A M "Report Upon the Reclamation of Water from Sewage and Industrial Wastes in Los Angeles County, California". April, 1949.

County Sanitation Districts of Orange County, California. "First Annual Report". June 30, 1955.

Goudey, R. F. "Sewage Reclamation Plant for Los Angeles". Western Construction News. October 25, 1930.

Hedger, H. E., and Rawn, A M "A Report Upon the Potential Reclamation of Sewage Now Wasting to the Ocean in Los Angeles County". November, 1958.

Jordan, L. W., and van der Goot, H. A. "Sewage Reclamation Spreading Test Adjacent to Azusa Sewage Treatment Plant". Los Angeles County Flood Control District. December, 1950.

Appendix A is a bibliography of reports and memoranda utilized in preparation of this report. References to the reports listed in the bibliography are designated in the text by arabic numerals in parentheses.

A brief summary of reclamation projects constructed and operated in the United States is presented in Appendix B. This summary was prepared from reports listed in Appendix A, and other data available in the files of this department and cooperating agencies.

Definitions of certain words or terms used in this report are contained in Appendix C.

Objectives of Investigation

It was assumed for purposes of this investigation that reports by this department and other agencies demonstrate the necessity of providing additional water supplies for the Los Angeles Metropolitan Area. The objectives of this investigation and report are therefore to discover:

1. The quantity and quality of water which can be reclaimed from waste water discharged to the ocean from the Los Angeles Metropolitan Area.

2. The costs of reclaimed water compared to imported supplies now in use or anticipated, including costs of transportation to places of use.

3. The possible general types of use to which reclaimed waters might be put without specific identification of the locations where the use would be accomplished.

Scope of Investigation and Report

This investigation included the determination of the quality and quantity of waste water supplies available at selected locations within the sewerage systems serving the Los Angeles Metropolitan Area. An extensive sampling program was undertaken at selected points within the sewerage systems of the City of Los Angeles during June 1955, and the County Sanitation Districts of Los Angeles County, during December 1955, in cooperation with those agencies for the purpose of determining the quantity and mineral quality of waste water available at these locations. Data on bacteriological characteristics were also completed and reported. A similar but less extensive sampling program was conducted during March 1955 within the sewerage system of the County Sanitation Districts of Orange County.

Because of the detailed nature of the sampling program, Chapter II of this report is devoted to a description of the methods and procedures employed. Chapter III presents the results of determination of the quantity of waste water flows at selected stations throughout the systems studied, and Chapter IV presents results of determinations of the mineral and sanitary quality of the waste water flows at these locations.

As previously mentioned, the necessity of providing supplemental water to meet the water requirements of the Southern California Area has been discussed in detail, and firmly established in reports of this department and other agencies. Consequently, a detailed discussion of water supply and requirements is not presented in this report. However, potential markets for, and beneficial uses of, reclaimed water were surveyed during the investigation to determine the types of water utilizing installations which might make use of reclaimed water and ascertain the order of magnitude of such markets. Since it was impossible to identify specific industries or other water using installations which would make use of the reclaimed water, data were developed on the various categories of water using operations to which reclaimed water would be applicable. Based upon this information, it was possible to develop plans for reclamation projects which would make water available for such uses. Special attention was given to the possibilities for use of reclaimed water for ground water recharge operations because of the already demonstrated applicability of waste water reclamation to this type of operation as evidenced by smaller scale programs of this nature presently in effect in many areas. Chapter V contains the results of these studies of potential markets for reclaimed water.

Plans were formulated to demonstrate the feasibility of construction of reclamation plants and appurtenant facilities required to divert sewage flows at selected points within the sewerage systems of the City of Los Angeles and the County Sanitation Districts of Los Angeles County, treat the water as required, and deliver the reclaimed water to the places of proposed use. Preliminary designs of these facilities were prepared to the degree of detail necessary to make adequate estimates of construction and operation costs. Sites for reclamation plants were examined in the field to ascertain their general suitability for the purposes intended. Alignments of conveyance facilities were generally located along streets and these lines were traveled in the field to ascertain major construction problems, such as stream and highway crossings, and interference with existing facilities. Layouts for cost estimating purposes were made on United States Geological Survey quadrangles.

Capital costs were estimated from unit price data available from construction bids for similar facilities employing price levels of September 1960. Annual costs were estimated, including recovery of capital costs with interest, and operation, maintenance and replacement estimated from operating experience for similar installations. From estimated annual costs, unit costs of water were computed for the various plans and comparisons made with current and anticipated costs of water from other available sources. Chapter VI contains the information developed on the various potential reclamation plans and detailed cost estimates are contained in Appendix D.

The plans presented in Chapter VI were prepared from data collected in 1955 and 1956. Since that time certain changes have occurred which generally are favorable to the plans formulated. Changes considered significant and pertinent are discussed in Chapter VII.

Chapter VIII of this report contains a summary of findings reached in the investigation and conclusions drawn therefrom.

There are attached to this report 22 plates which illustrate and supplement the textual material presented.

Area of Investigation

The area to which this investigation was devoted is that generally referred to as the Los Angeles Metropolitan Area. Because of the nature of the study, primarily dealing with waste water discharges and their re-use, the actual areal coverage included localities where waste water flows are, or could be, collected and discharged to outfalls and to adjacent areas where use could be made of reclaimed water.

The area studied as shown on Plate 1, entitled "Location of Area of Investigation", and in more detail on Plate 2, entitled "Major Sewerage Facilities in Los Angeles Metropolitan Area, 1955", comprises about 1,820 square miles, consisting of the City of Los Angeles and neighboring cities and county areas from Santa Monica to Newport Beach. It includes the drainage basins of the Los Angeles and San Gabriel Rivers and Ballona Creek and their tributaries south of the Angeles National Forest boundary, except where city boundaries extend north of the national forest, in which cases the limit of the area is the northerly boundaries of the cities. The area also includes the Orange County portion of the Santa Ana River drainage basin downstream from the Santa Ana Narrows. Along the coast line, it includes the areas directly tributary to the Pacific Ocean from the drainage basin of Topanga Canyon on the north, to Pelican Point two miles south of the entrance to Newport Bay on the south. It will be noted that waste water flows from Claremont Heights, Live Oak, Pomona, and Spadra ground water basins located along the eastern border of Los Angeles County enter the Los Angeles County Sanitation Districts system, although they are shown outside the area of investigation. No specific studies were made for these areas in this investigation since it is planned to include them in a subsequent investigation in the Upper Santa Ana Valley.

The Los Angeles Metropolitan Area has experienced phenomenal growth during the past 60 years. The population has increased from about 190,000 in 1900, to over 6,400,000 in 1960. This increase in population brought about rapid urban development, and a reduction in the area devoted to agriculture. A natural result of the increased urbanization was a parallel increase in water demand and production of waste waters. The disposal problems of domestic and industrial waste waters led to installation of extensive sewerage systems to serve the urban areas.

Agencies responsible for waste water disposal within the area have found that the most convenient and economical method of disposal is to discharge it to the ocean through large outfall sewers. Thus, more than 99 percent of the waste water discharged to the ocean from the Los Angeles Metropolitan Area is derived from four major sewerage systems. Two of these sewerage systems are owned and operated by the City of Los Angeles, and the remaining two by the County Sanitation Districts of Los Angeles County and the County Sanitation Districts of Orange County. The locations of the major sewerage facilities operated by these three agencies in 1955 are shown on Plate 2.

The City of Los Angeles operates two main sewerage systems. The larger system drains the city's area in the San Fernando Valley and northern portions of the Los Angeles County Coastal Plain discharging to trunk sewers leading to Hyperion Treatment Plant which in 1955 was equipped with a marine outfall discharging to Santa Monica Bay. Chapter VII describes plant improvements completed since 1955. A smaller system drains the Wilmington-San Pedro Harbor area and discharges to the Terminal Island Treatment Plant and marine outfall.

The sewerage system of the County Sanitation Districts of Los Angeles County drains the Upper San Gabriel Valley and the southerly portions of the Los Angeles Coastal Plain discharging to the Joint Disposal Plant located near Lomita, which in turn discharges through the Whites Point tunnels and two ocean outfalls westerly of San Pedro Bay.

The sewerage system of the County Sanitation Districts of Orange County drains primarily the coastal plain areas of Orange County discharging through Plants No. 1 and No. 2 to an ocean outfall between Huntington Beach and Newport Bay.

More detailed discussions of the foregoing sewerage facilities are contained in subsequent chapters of this report.

Sampling Sewage at a Manhole

" .... sampling stations were selected, and grab samples were collected from each station ...."

CHAPTER II. PROCEDURE FOR SAMPLING AND MEASUREMENT OF WASTE WATER FLOW

Cooperation and assistance in conducting the detailed sampling and flow measurement program for the sewerage systems in the Los Angeles Metropolitan Area were obtained from each of the three public agencies operating principal sewerage systems. These agencies are the City of Los Angeles, the County Sanitation Districts of Los Angeles County, and the County Sanitation Districts of Orange County. Separate sampling and flow measurement programs were completed for systems of each of these agencies and the procedures used in conducting the programs are described in this chapter.

City of Los Angeles Sewerage Systems

The sampling and flow measurement program for the two City of Los Angeles systems extended over a two week period from June 17 through June 30, 1955, during which time samples and flow measurements were obtained from treatment plants and sampling stations at the locations shown on Plate 2.

During the first week of the program, June 17 through June 23, samples and flow measurements were obtained from five stations, three at manholes along the Glendale Outfall Sewer at Partridge Avenue, at Fourth Street and Mission Road, and at Eighth Street and Mission Road, and one each at the influent to and effluent from the Valley Settling Basin.

During the second week of the program, samples and flow measurements were obtained from eight stations. These stations were at Manhole No. 1 and Manhole No. 15 on the North Outfall Sewer, the Central Outfall Sewer near Florence Avenue and Ash Avenue, the Venice Pumping Plant, the influent to and effluent from the primary clarifiers and effluent from the secondary clarifiers at Hyperion Treatment Plant, and effluent from the Terminal Island Treatment Plant.

The procedure followed in conducting the program was essentially the same during each of the two weeks, except that during the first week samples were analyzed at temporary departmental laboratory facilities established at the Valley Treatment Plant, and during the second week temporary laboratory facilities were established at the Hyperion Treatment Plant. However, it was found desirable to modify the program at certain of the stations as noted in the following discussions.

City of Los Angeles personnel, operating on three shifts, collected hourly grab samples from the aforenamed stations at the trunk sewers, treatment plants, and pumping plants for seven days straight. Flow measurements were made and temperature of samples recorded at the time of sampling. Samples were delivered to the temporary departmental laboratory facilities at the end of each eight-hour shift, and conductivity and chloride concentration of each sample were determined and recorded. Complete mineral analysis was made of each sample showing highest conductivity and/or chloride concentration for each day. A daily composite was made from the 24 hourly grab samples composited in proportion to the flow. A weekly composite was made from the daily composites.

The daily composite samples were subjected to complete mineral analysis, as well as determinations of settleable and suspended solids, fixed volatile solids, orthophosphate, and ammonia. Weekly composite samples were subjected to both a complete mineral analysis and a trace metal analysis.

On selected days, hourly grab samples were taken for phenol determinations. During another selected period, samples were taken every six hours for two days for biochemical oxygen demand determination at sampling points on trunk sewers. These samples were iced immediately and delivered to the State Department of Public Health laboratory for analysis.

During periods when the Valley Settling Basin was in operation, samples and flow measurements were obtained at influent and effluent points. Samples and flow measurements were first obtained from the station at Manhole No. 15 during an eight hour period on June 30, 1955; however, turbulence made flow measurements unreliable at that station, and the remainder of the measurements were made at Manhole No. 1 on the North Outfall Sewer.

Samples and flow measurements were obtained at four-hour intervals throughout each 24 hour day for a period of one week at the Venice Pumping Plant. At the Terminal Island Treatment Plant, however, samples and flow measurements were obtained only during the period from 8 a.m. till 11 a.m. each day for a week. This latter routine was found to produce sufficiently valid data for the purposes of studying this plant.

County Sanitation Districts of Los Angeles County

The sewerage system of the County Sanitation Districts of Los Angeles County receives a relatively larger proportion of mineralized industrial waste discharges than the sewerage system of the City of Los Angeles. Because of this, and because of the resulting high salinity of the total discharge to the Joint Disposal Plant, additional preliminary observations were made at various points on this sewerage system prior to initiating the week-long sampling program. Major waste discharges and chloride concentrations in the three main systems entering the Joint Disposal Plant were obtained from the districts. On the basis of these data, 19 tentative sampling stations were selected, and grab samples collected from each station were analyzed for chloride concentration and electrical conductivity. Estimates of average daily flow were obtained, and the suitability of the stations was discussed with personnel of the County Sanitation Districts of Los Angeles County.

On the basis of this information, four sampling stations, located as shown on Plate 2, were chosen for the sampling and flow measurement program which was conducted during the week of December 5 through December 12, 1955. Continuous sampling devices were installed by personnel of the County Sanitation Districts to obtain composite daily samples, and continuous water stage recorders were installed upstream of each station to obtain simultaneous continuous depth of flow measurements.

Two or more grab samples were collected by County Sanitation Districts personnel each day of the sampling period from each station, one during low flows, one during high flows, and others at irregular intervals. Daily samples from the continuous samplers were collected at the same time as the high flow grab samples by the County Sanitation Districts personnel. Two grab samples for biochemical oxygen demand determinations, one during low flows and the other during high flows; and three grab samples for phenol determinations, one during low flows and two during high flows were collected at selected times from each station by Department of Water Resources personnel.

Temporary laboratory space was provided for department personnel at the Joint Disposal Plant to run partial mineral analyses on the grab and continuous samples, prepare composite samples from the grab samples, and analyze the samples collected for phenol determination.

Each grab sample was analyzed for electrical conductivity, chloride concentration, and pH. The grab samples were then composited in proportion to flow to obtain a daily sample from each station to be analyzed for settleable and suspended solids. These daily composite samples were in turn composited to obtain a weekly sample from each station which was subjected to a spectrographic estimate for selected metals, and also given a complete mineral analysis plus an analysis for silica, total nitrogen, nitrite nitrogen, orthophosphate, and total and fixed dissolved solids.

The daily samples from the continuous sampling devices at each station were analyzed for electrical conductivity, chloride concentration, and pH at the temporary laboratory, and later subjected to a complete mineral analysis plus an analysis for silica, total nitrogen, nitrite nitrogen, orthophosphate, total and fixed dissolved solids, suspended solids, and settleable solids. The daily samples from the continuous sampling devices were composited in proportion to flow to obtain a weekly sample from each station for analysis for trace metals.

The special grab samples for biochemical oxygen demand determination were iced immediately after collection and delivered to the State Department of Public Health laboratory for analysis.

County Sanitation Districts of Orange County

The County Sanitation Districts of Orange County provide sewerage facilities for most of the incorporated cities in Orange County. The districts operate two primary sewage treatment plants which discharge to the same marine outfall. During the period from March 20 through March 26, 1955, a detailed sampling and flow measurement program was carried out at both treatment plants.

A large portion of the total flow through the districts' system consists of brine discharged from oil field operations in northern Orange County. The system is so designed that these brines can be diverted to trunk lines which bypass Plant No. 1 and go directly to Plant No. 2. Flow in the trunk lines was routed by the county agency so that only domestic sewage with limited amounts of industrial wastes entered Plant No. 1 during the week of March 20 through March 26, 1955.

Grab samples were taken of the effluent of Plant No. 1 every two hours for seven consecutive days. Chloride and conductivity determinations were made on each grab sample, and daily composites of these samples were prepared. The sample or samples showing the highest conductivity and/or chloride concentrations were saved for complete analyses. In addition, daily composite samples of the effluent from Plant No. 1 were collected by a continuous sampler which automatically composited the sample in proportion to flow. Weekly composite samples were prepared from both the daily samples obtained from the continuous sampler and from the daily composite samples obtained from the bihourly grab samples.

Grab samples of the effluent from Plant No. 1 were collected every two hours for the three-day period March 20 through March 22, 1955, for determination of phenol concentrations. The samples were combined to produce a composite sample for each day prior to analysis.

At Plant No. 2, daily composite samples of the effluent were obtained by compositing bihourly grab samples in proportion to flow.

Individual grab samples were not analyzed. Weekly composite samples, also combined in proportion to the flow, were prepared from the daily composite samples.

All samples at both plants were collected by Sanitation Districts personnel. Conductivity and chloride determinations were made jointly by department personnel and the County Sanitation Districts chemist.

Complete mineral analyses were made by departmental personnel of the daily and weekly composite samples from both plants, and of grab samples taken at Plant No. 1 showing highest conductivity and/or chloride concentration for any one day. These analyses included determination of orthophosphate and total and fixed dissolved solids. Weekly composite samples were also examined for trace metals.

Water Stage Recorder in Manhole

"Water stage recorders were installed at each of the sampling stations ...."

CHAPTER III. QUANTITATIVE MEASUREMENTS OF WASTE WATER FLOWS

Measurements of the quantity of waste water flowing past the sampling stations discussed in the preceding chapter were made to provide a basis for estimating the quantity of waste water which would be available for possible diversion, treatment, and re-use at various points throughout the four sewerage systems belonging to the City of Los Angeles, the County Sanitation Districts of Los Angeles County, and the County Sanitation Districts of Orange County. The 19 stations selected for sampling and flow measurement are described in detail in this chapter and results of flow measurements are reported.

Historical Conditions

The Los Angeles Metropolitan Area has experienced extensive growth of urban areas, resulting in extension of sewerage facilities and the abandonment of land disposal practices, rapidly increasing the discharge of waste water to ocean outfalls. Annual discharge of waste water to the ocean from the Metropolitan Area for the 36-year period 1924-25 through 1959-60 by the three agencies operating major sewerage systems is presented in Table 1 and graphically depicted on Plate 3, entitled "Historical Discharge of Sewage and Industrial Waste to the Ocean from the Los Angeles Metropolitan Area". The total discharge has increased nearly 600 percent during the 36-year period. From 1939-40 to 1959-60 the flow from the City of Los Angeles sewerage systems increased about 95 percent, while the flow from the County Sanitation Districts of Los Angeles County sewerage system increased about 840 percent. The latter large increase in flow is more attributable to extension of the district's sewerage system than an increase in population density.

TABLE 1

HISTORICAL DISCHARGE OF WASTE WATER TO THE OCEAN
FROM THE LOS ANGELES METROPOLITAN AREA

In acre-feet

Season ending June 30	City of Los Angeles		County Sanitation Districts of Los Angeles County	County Sanitation Districts of Orange County and predecessor agencies	Total for the three public agencies operating principal sewerage systems
	Hyperion	Terminal Island			
1924-25	88,600	2,500	--	4,000	95,100
26	94,700	2,500	--	4,300	101,500
27	97,600	2,500	--	4,500	104,600
28	99,000	2,500	2,200	4,300	108,000
29	117,400	3,200	6,300	5,000	131,900
1929-30	122,200	3,200	10,600	5,200	141,200
31	126,100	3,200	12,200	4,900	146,400
32	127,800	3,200	14,600	5,200	150,800
33	126,400	3,200	14,900	4,800	149,300
34	114,100	3,200	16,000	4,700	138,000
1934-35	125,200	3,200	17,600	5,200	151,200
36	127,500	3,500	20,800	5,600	157,400
37	142,800	3,900	20,600	6,500	173,800
38	145,600	2,800	25,300	7,300	181,000
39	146,500	3,500	27,200	7,300	184,500
1939-40	149,800	3,300	30,600	7,000	190,700
41	164,600	3,800	35,500	7,000	210,900
42	159,800	4,000	37,600	7,300	208,700
43	161,500	5,300	46,000	7,900	220,700
44	181,700	6,400	56,000	8,500	252,600

HISTORICAL DISCHARGE OF WASTE WATER TO THE OCEAN
FROM THE LOS ANGELES METROPOLITAN AREA
(continued)

In acre-feet

Season ending June 30	City of Los Angeles		County Sanitation Districts of Los Angeles County	County Sanitation Districts of Orange County and predecessor agencies	Total for the three public agencies operating principal sewerage systems
	Hyperion	Terminal Island			
1944-45	178,700	6,600	57,000	9,400	251,700
46	180,300	6,600	60,000	9,900	256,800
47	199,600	7,000	64,000	11,000	281,600
48	213,100	6,300	80,000	11,200	310,600
49	222,500	6,400	112,000	11,700	352,600
1949-50	217,000	6,400	122,000	11,700	357,100
51	227,200	5,600	137,000	12,600	382,400
52	246,000	6,300	157,000	14,600	423,900
53	257,600	5,900	166,000	15,900	445,400
54	267,900	6,200	184,000	15,300	473,400
1954-55	273,200	6,800	201,000	23,400	504,400
56	279,800	6,800	203,000	30,700	520,300
57	287,000	6,800	214,000	38,200	546,000
58	299,400	6,900	239,000	45,300	590,600
59	293,200	6,900	264,000	53,900	618,000
1959-60	290,700	7,200	289,000	60,300	647,200

Conditions Extant During Investigation

During the period 1954-55 through 1959-60, ocean disposal of waste water from the Los Angeles Metropolitan Area increased from about 505,000 acre-feet per year to about 648,000 acre-feet per year. Of the total quantity of waste water discharged to the ocean from the Metropolitan Area, more than 99 percent is discharged through the four principal sewerage systems. The relative magnitudes and general locations of the flows through the four systems during 1954-55 are schematically illustrated on Plate 4, entitled "Schematic Diagram of Quantity and Mineral Quality of Sewage Flow for Major Sewage Disposal Systems Discharging to Ocean, 1954-55". Mineral quality data shown on this plate are discussed later in this report.

The fluctuation of waste water flow with time is of considerable importance in determining the feasibility of reclamation of water from wastes, since without storage a firm supply is determined by the minimum flows. The monthly variation in discharge to the ocean for the period July 1954 through June 1960 by the three agencies operating major sewerage systems is graphically depicted on Plate 5. Inspection of this plate will indicate that the monthly variation in flow is quite small.

There are four additional sewerage agencies in the Los Angeles Metropolitan Area that discharge relatively small quantities of waste water to the Pacific Ocean or its tidal waters. In order of magnitude of discharge these agencies are the City of Seal Beach, Sunset Beach Sanitary District, the Los Alamitos Naval Air Station, and the United States Navy Ammunition and Net Depot. The combined discharge of these four agencies amounts to less than one percent of the total ocean discharge from the area of investigation and was considered insignificant for the purposes of this investigation.

Only waste water discharges to the Pacific Ocean or its tidal waters are deemed available for planned reclamation, though effluents discharged to the land may bring about involuntary reclamation. Ocean disposals of industrial wastes independent of the afore-mentioned facilities have not been considered in this report because of the extremely limited quantity and generally poor quality of such discharges.

The quantities of waste water discharged to the ocean by public agencies during 1954-55 and 1959-60 are summarized in Table 2.

Flow was measured at 18 of the 19 sampling stations discussed in Chapter II and described in detail hereinafter during the week of sampling at each station. These flow measurements are believed to be representative of flows occurring at these stations during 1955. Results of flow measurements at all of these stations are presented in Table 3 except for the effluent from the Valley Treatment Plant and from the primary and secondary facilities at Hyperion Treatment Plant. These flows are not listed since they were essentially the same as the inflow to the respective plants during the week.

A description of each of the sampling stations together with a discussion of the flow measurements obtained at each station is presented in the following paragraphs. The stations are discussed in geographic order for each owner agency commencing with the most upstream station on each system.

City of Los Angeles

This agency operates two separate sewerage systems. The smaller system serves the Los Angeles Harbor area and discharges into San Pedro Bay. Primary treatment for this discharge is provided at the Terminal

TABLE 2

OCEAN DISCHARGE OF WASTE WATER FROM THE LOS ANGELES METROPOLITAN AREA
DURING FISCAL YEARS 1954-55 AND 1959-60

Agency and sewerage system	Average rate of discharge, in millions of gallons per day		Total discharge, in acre-feet		Discharge, in percent of total discharge from area	
	During 1954-55	During 1959-60	During 1954-55	During 1959-60	During 1954-55	During 1959-60
City of Los Angeles						
Hyperion	243.9	259.5	273,200	290,700	54.1	44.8
Terminal Island	6.1	6.4	6,800	7,200	1.4	1.2
County Sanitation Districts of Los Angeles County	179.4	257.4	201,000	289,000	39.8	44.6
County Sanitation Districts of Orange County	20.8	53.7	23,400	60,300	4.6	9.3
City of Seal Beach	0.3	0.6	300	700	Less than 0.1	Less than 0.1
Sunset Beach Sanitary District	0.1*	0.2*	100*	200*	Less than 0.1	Less than 0.1
Los Alamitos Naval Air Station	0.1	0.1	100	100	Less than 0.1	Less than 0.1
United States Navy Ammunition and Net Depot	0.1	0.1	100	100	Less than 0.1	Less than 0.1
TOTALS	450.8	578.0	505,000	648,300	100	100

* Estimated.

TABLE 3

FLOWS AT SAMPLING STATIONS IN THE
LOS ANGELES METROPOLITAN AREA IN 1955

Agency and station	Average flow during week of sampling: In millions of gallons per day	In cubic feet per second	In acre-feet per year
<u>City of Los Angeles</u>			
Valley Settling Basin influent	7.6	11.8	8,500
Glendale Outfall Sewer			
at Partridge Avenue	47.1	73.0	52,800
at Fourth Street and Mission Road	44.0	68.0	49,200
at Eighth Street and Mission Road	53.7	83.1	60,200
North Outfall Sewer at Manhole No. 1 near Sepulveda Boulevard	187.6	290.3	210,100
Central Outfall Sewer north of intersection of Florence and Ash Avenues	33.3	51.6	37,300
Venice Pumping Plant	15.0	23.2	16,800
Hyperion Treatment Plant influent	233.5	361.2	261,500
Terminal Island Treatment Plant	6.2	9.5	6,900
<u>County Sanitation Districts of Los Angeles County</u>			
Joint Outfall "B" at intersection of Loma Avenue and Klingerman Street	29.3	45.3	32,800
South Whittier Outfall south of Imperial Highway on Carmenita Road	5.7	8.8	6,300
Joint Outfall "G" west of intersection of Bort Street and Gale Avenue	19.0	29.4	21,300
Joint Outfall "E" north of Greenleaf Drive on Alameda Street	12.6	19.5	14,100
<u>County Sanitation Districts of Orange County</u>			
Plant No. 1	5.8	9.0	6,500
Plant No. 2	14.6	22.5	16,300

Island Sewage Treatment Plant. During the fiscal year 1954-55, the flow through this plant amounted to 6,800 acre-feet as measured by permanently installed flow measuring devices at this plant.

The Hyperion system which discharges into Santa Monica Bay, serves the City of Los Angeles, including the San Fernando Valley portion, and the Cities of San Fernando, Burbank, Glendale, Beverly Hills, Santa Monica, and Culver City. Secondary treatment, using a high rate activated sludge process, was provided for this discharge at the Hyperion Treatment Plant at the time of sampling, and at the present time (1960) between one-third and one-half of the flow through the plant receives secondary treatment by the standard rate activated sludge process. The balance of the flow is given primary treatment and the entire flow is discharged to ocean outfalls. During fiscal year 1954-55, the flow through this plant amounted to 273,200 acre-feet as measured by permanently installed flow measuring devices at this plant.

During the investigation that led to this report thirteen sampling stations were established on the Los Angeles City sewerage systems to obtain mineral and sanitary quality data at possible diversion points. Five of the stations were located at the Valley Settling Basin and Hyperion Treatment Plant, one each at the Venice Pumping Plant and the Terminal Island Treatment Plant, and the remaining six stations were established at selected manholes on trunk sewers. Measurements of depth of flow were made at five of the stations established on trunk sewers as samples were collected, and flow at each of these stations was calculated by correlating these hourly measurements with the hydraulic properties of the particular sewer. The locations of these stations are delineated on Plate 2.

Valley Settling Basin. This plant is located south of the Los Angeles River and west of the City of Glendale in the San Fernando Valley. It was built to provide temporary storage of 786,000 gallons to relieve the overtaxed Glendale Outfall Sewer, which serves the San Fernando Valley area. Under initial operating conditions, a portion of the daily peak flow in the trunk sewer was bypassed into the plant, retained there, and discharged into the trunk sewer during the daily off-peak period. This method of disposal became inadequate when the average daily flow from the San Fernando Valley exceeded the maximum capacity of the Glendale Outfall Sewer. As an emergency measure, the Valley Settling Basin was operated as a treatment plant and the treated effluent was discharged into the Los Angeles River. This condition existed during June 1955, at the time of the sampling program. Completion of the San Fernando La Cienega Relief Sewer through the Santa Monica Mountains in 1956, and other subsequent construction has relieved the overload on the Glendale Outfall Sewer. However, the Valley Settling Basin is still operated when necessary to handle peak wet weather flows.

During the sampling program, June 17 through 23, 1955, two stations were established at the Valley Settling Basin, one station for sampling and measuring the influent to the plant and the other for sampling and measuring effluent from the plant. The plant was operated from about 9 a.m. to midnight. Actual time of diversion of flows from the Glendale Outfall Sewer was somewhat less than the indicated 15 hours per day because the plant was operated only as required to divert peak flows in the sewer. Measurements of water diverted from the sewer are graphically depicted on Plate 6. The rate of flow for the week during periods of diversion averaged 13.9 million gallons per day; however, since the plant was operated only during part of each day, the average flow for the week was 7.6 million gallons per day.

During June 1955, a minor portion of the sewage treated at the plant was returned to the Glendale Outfall Sewer and the remainder discharged directly into the Los Angeles River. Of the total flow diverted into the Valley Settling Basin in June 1955, 11 percent or 0.8 million gallons per day was returned to the sewer during off-peak periods and 89 percent or 6.8 million gallons per day was discharged to the Los Angeles River. This condition is not reflected in current operations but may be expected to recur if and when the situation demands.

Glendale Outfall Sewer at Partridge Avenue. During 1955, the Glendale Outfall Sewer at Partridge Avenue carried the waste water outflow from the San Fernando Valley, including the waste water flows from the Cities of Glendale and Burbank, except for that portion discharged to the Los Angeles River from the Valley Settling Basin.

Instantaneous flow past the Partridge Avenue station was calculated from hourly depth of flow measurements for the period June 17 through 23, 1955. A hydrograph of the flow is presented on Plate 7. During the week of flow measurement, the average discharge was 47.1 million gallons per day or about 20 percent of the flow through the Hyperion Treatment Plant. Daily discharges varied from a low on Sunday of 44.5 million gallons to a high of 48.5 million gallons on Tuesday. During the week, the minimum and maximum instantaneous flows were 55 and 124 percent, respectively, of the corresponding daily average flows. The operation of the Valley Settling Basin has a dampening effect on the percentage variation of maximum and minimum flows. That is, minimum flows are higher than they would otherwise be since flow is returned to the sewer during off-peak periods, and similarly peak flows are reduced because a portion of the peak flow is diverted to the Valley Settling Basin.

Glendale Outfall Sewer at Mission Road. A sampling station was first established on Glendale Outfall Sewer at Mission Road about midway between Seventh Street and Olympic Boulevard, six miles downstream from the Partridge Avenue station, near the point where Eighth Street would intersect Mission Road if it were projected. This station was selected because a potential diversion point was nearby, and because it was immediately downstream of the junction of the Glendale Outfall Sewer and a large trunk sewer which carries the sewage from the eastern portion of the City of Los Angeles, as shown on Plate 2.

It was found that accurate flow measurements could not be made at this location because of a side flow discharging into the manhole at this intersection. For this reason an alternative sampling point was substituted at Fourth Street and Mission Road, upstream of the junction of the Glendale Outfall Sewer and the trunk sewer from the east.

A hydrograph of the flow at the Fourth Street and Mission Road station is presented on Plate 8. The average flow past this station for the week of June 17 through 23, 1955, was 44.0 million gallons per day. The daily discharge varied from a low on Sunday of 40.3 to a high of 45.8 million gallons per day on Tuesday. The minimum and maximum flows were 55 and 131 percent, respectively, of the corresponding daily average flows. The average flow past the Fourth Street and Mission Road station was about 82 percent of the flow at Eighth Street and Mission Road and 19 percent of the total flow through the Hyperion Treatment Plant.

North Outfall Sewer. A sampling station on this vital trunk sewer was required to obtain data on quantity and quality of waste water flows prior to mixing with the Venice Pumping Plant line. These data were necessary to evaluate the quantity and quality of waste water flows which would be available for diversion from the North Outfall Sewer at the Hyperion Sewage Treatment Plant if flows from the Venice Pumping Plant line were not intermixed with the other waste water.

A sampling station was initially selected at Manhole No. 15, located between Lincoln Boulevard and the junction of the North Outfall Sewer with the Venice Pumping Plant line, as shown on Plate 2, so that flows in this sewer could be sampled immediately upstream from that junction. Because of poor conditions for flow measurement at this station, Manhole No. 1, further upstream between Lincoln and Sepulveda Boulevards, was substituted. The flow in this main outfall sewer was determined from hourly measurements of depth of flow at Manhole No. 1 for the period June 24 through 30, 1955. A hydrograph of the flow past Manhole No. 1 is presented on Plate 9. Flow past this station averaged 188 million gallons per day for the week and constituted about 80 percent of the flow through the Hyperion Treatment Plant. The daily discharge varied from a low of 163 million gallons on Sunday to a high of 197 million gallons on Monday. The minimum and maximum flows were 51 and 140 percent, respectively, of the corresponding daily average flow.

Central Outfall Sewer. A sampling and flow measurement station was established on this trunk sewer north of the intersection of Florence and Ash Avenues. This station was established to secure data necessary to evaluate the quantity and quality of waste water flow which would be available for diversion at the Hyperion Sewage Treatment Plant if flows from the Venice Pumping Plant line were not intermixed with other sewage upstream from the point of diversion. Flow past this station was determined from hourly measurements of the depth of flow during the period June 24 through 30, 1955. The average discharge past this station was 33.3 million gallons per day during the week of measurement and constituted about 14 percent of the flow through the Hyperion Treatment Plant. Daily flows varied from a low of 23.7 million gallons on Sunday to a high of 37.1 million gallons per day on Tuesday and Friday. The minimum and maximum flows were 37 and 158 percent, respectively, of the corresponding daily average flow. A hydrograph of the flow at this station is presented on Plate 10.

Venice Pumping Plant. A sampling station was established at the Venice Pumping Plant. The sewerage system upstream of this plant serves the City of Santa Monica and the Venice area. The mineral quality of the flow reaching the Venice Pumping Plant is greatly deteriorated as a result of the infiltration of saline waters into the trunk sewer. The effluent from this plant was sampled at four-hour intervals during the week-long sampling program to evaluate its effect on the mineral quality of the flow at the Hyperion Treatment Plant. Because it would apparently not be practicable to reclaim any of this waste water, more frequent sampling was not considered necessary. Data obtained were sufficient to evaluate the quantity and quality of waste water which would be available for diversion at the Hyperion Treatment Plant if flow in this line were not intermixed with flow from other trunk sewers upstream from the point of diversion.

There are no flow metering devices at the Venice Pumping Plant. Estimates of the discharge of sufficient accuracy for use in this study were obtained by noting what pumps were operating at the time of sampling and correlating this information with data regarding pump discharge capacities supplied by the City of Los Angeles. Since samples were collected only every four hours, estimates of instantaneous flow were made only at four-hour intervals. A hydrograph of the discharge from this plant was constructed on the basis of these data and is presented on Plate 11.

During the week of flow measurement, June 24 through 30, 1955, an average of 15.0 million gallons per day was pumped through this plant. This amount constituted about six percent of the flow through the Hyperion Treatment Plant.

Hyperion Treatment Plant. The flow through the Hyperion Treatment Plant is measured by venturi meters at the influent to the primary clarifiers. During the week of June 24 through 30, 1955, samples were collected of the influent to and effluent from the primary clarifiers, and of the effluent from the secondary clarifiers. The hourly flow measurements recorded at the influent to the primary clarifiers are presented as a hydrograph on Plate 12. Average daily discharges obtained from continuous flow charts are also plotted on Plate 12. During the week of sampling, the flow past this station averaged 233.5 million gallons per day. The daily flow varied from a low of 196 million gallons on Sunday to a high of 250 million gallons on Friday. Minimum and maximum flows were 48 and 139 percent, respectively, of the corresponding daily average flow.

During the month of June 1955, the average daily flow through the Hyperion Treatment Plant was 242 million gallons per day. For the season July 1954, through June 1955, the average daily flow was 244 million gallons per day.

Terminal Island Treatment Plant. The facilities described above are all part of the sewerage system of the City of Los Angeles which discharges waste waters to the ocean through the Hyperion Treatment Plant, except for emergency discharges to the Los Angeles River from the Valley Settling Basin. In addition to this very large system, the City of Los Angeles owns and operates a comparatively small system which discharges waste waters to the ocean through the Terminal Island Treatment Plant. During the week of June 24 through 30, 1955, a sampling station was established at the Terminal Island Treatment Plant and hourly flow measurements were made between the hours of 8 a.m. and midnight, when an operator was on duty at the plant. A discontinuous hydrograph of these measured flows is presented on Plate 13. From additional data obtained from the City of Los Angeles, it was computed that the average flow through the plant during the week of sampling was 6.3 million gallons per day.

County Sanitation Districts of Los Angeles County

This agency operates a sewerage system which discharges waste waters into the Pacific Ocean at Whites Point on the southeast side of the Palos Verdes peninsula. The waste water flowing through this system is treated at the Joint Disposal Plant, located approximately six miles northeast of Whites Point as shown on Plate 2. This plant provides primary treatment for waste water flows from a large portion of coastal Los Angeles County outside of the Los Angeles City limits. Flow through this plant during the fiscal years 1954-55 and 1959-60 amounted to about 201,000 acre-feet and 289,000 acre-feet, respectively.

Four sampling stations were established on trunk sewers of this system during the week of sampling, December 5 through 12, 1955, to obtain mineral and sanitary quality data at possible diversion points. The locations of these sampling stations are shown on Plate 2. Water stage recorders were installed at each of the sampling stations to obtain a continuous record of the depth of flow at each station. In addition, depth of flow measurements were made at each of these stations at the same times that samples were collected to check these recorder measurements. From both sets of data, and from data concerning the hydraulic properties of the particular sewer, continuous hydrographs were prepared. These hydrographs are presented on Plate 14.

Joint Outfall "B". A sampling station was established on this outfall at the intersection of Loma Avenue and Klingerman Street near Whittier Narrows. The outfall sewer upstream of the sampling station serves all or portions of the cities and communities of Pasadena, South Pasadena, Altadena, Alhambra, San Marino, San Gabriel, Sierra Madre, Monrovia, Arcadia, El Monte, and portions of other adjacent areas in the San Gabriel Valley. Flows past this station averaged 29.3 million gallons per day for the period December 6 through 11, 1955, or 16.6 percent of the total flow through the Joint Disposal Plant.

The daily discharge varied from a low of 27.5 million gallons on Tuesday to a high of 29.9 million gallons on Wednesday during the week of sampling. Minimum and maximum flows were 32 and 172 percent, respectively, of the corresponding daily average flow.

South Whittier Outfall. A sampling station was established south of Imperial Highway on Carmenita Road on the outfall sewer which serves the

City of Whittier and vicinity. Flows past this station averaged 5.7 million gallons per day for the period December 6 through 11, 1955, and constituted 3.2 percent of the total flow through the Joint Disposal Plant. The daily flow during the period of sampling varied from a low of 5.5 million gallons on Friday to a high of 5.9 million gallons on Sunday. Minimum and maximum flows were 31 and 179 percent, respectively, of the corresponding daily average flow.

Joint Outfall "G". A sampling station was located on the joint outfall sewer west of the intersection of Bort Street and Gale Avenue, in the North Long Beach vicinity. Joint outfalls "G" and "E" service the area of Vernon, Maywood, Bell, Huntington Park, South Gate, Lynwood, and Compton. At the sampling station on joint outfall "G", the flows constituted about 60 percent of the total flow from these areas during the week of sampling. Flow past this station during the same period averaged 19.0 million gallons per day or 10.8 percent of the flow through the Joint Disposal Plant. The daily flow for the same period varied from a low of 16.5 million gallons on Tuesday to a high of 22.5 million gallons on Wednesday. Minimum and maximum flows were 37 and 204 percent, respectively, of the corresponding daily average flow.

Joint Outfall "E". A sampling station was located on the joint outfall sewer, north of Greenleaf Drive on Alameda Street, and one mile northwest of the station on joint outfall "G" in the southern portion of Compton. The flow passing the station on joint outfall "E" amounted to 40 percent of the total flow from the areas served by joint outfalls "G" and "E" during the week of sampling. Flow past this station during the week of sampling averaged 12.6 million gallons per day or 7.1 percent of the flow through the Joint Disposal Plant. The daily flow during the week of sampling varied from a low of 9.2 million gallons on Sunday to a high of 13.7 million gallons on Tuesday. Minimum and maximum flows were 41 and 141 percent, respectively, of the corresponding daily average flow.

County Sanitation Districts of Orange County

This agency operates two primary treatment plants which serve the Cities of Santa Ana, Anaheim, Fullerton, Orange, Huntington Beach, and Newport Beach, and also the sanitary districts of Placentia, Garden Grove, La Habra, and Buena Park. Waste water flows discharged to the ocean from the two treatment plants amounted to 23,400 acre-feet during the fiscal year 1954-55.

The Talbert Water District, comprising an area of 2,500 acres in the Santa Ana Gap in Orange County was formed primarily to act as a water reclamation agency. The Talbert Water District is utilizing effluent from Plant No. 1 for the preirrigation of beans, and may subsequently irrigate other crops. To facilitate this diversion, flow from the Euclid-Verano trunk is diverted directly to Plant No. 2, thereby improving the mineral quality of the effluent from Plant No. 1. By this arrangement only the primarily domestic sewage flows from the Santa Ana and Costa Mesa trunk sewers enter Plant No. 1.

Plant No. 1. This plant, located near the west bank of the Santa Ana River at Ellis and Verano Avenues, discharges its effluent into a trunk sewer line which follows the Santa Ana River and discharges along with effluent from Plant No. 2 into the marine outfall sewer. During the week of sampling, March 20 through 26, 1956, only the flows from Santa Ana and about 50 percent of the flows from Costa Mesa were received by Plant No. 1. The flow from the Euclid-Verano trunk sewer was bypassed to Plant No. 2. The flow into Plant No. 1 during that period averaged 5.8 million gallons per day, or 28 percent of the average daily flow from the County Sanitation Districts of Orange County. During the week of sampling, daily flow varied from a low of 4.7 million gallons on Sunday to a high of 6.7 million gallons on Friday, as shown on Plate 15.

Plant No. 2. This plant, located at Pacific Coast Highway and the mouth of the Santa Ana River, discharges its effluent through a marine outfall into the waters of the Pacific Ocean. During the week of sampling, March 21 through 27, 1956, all of the flows from the Cities of Anaheim, Fullerton, Orange, Huntington Beach, and Newport Beach; the sanitary districts of Placentia, Garden Grove, La Habra, and Buena Park; and about 50 percent of the flows from Costa Mesa were treated at this plant. Flow through this plant during the sampling period averaged 14.6 million gallons per day or 72 percent of the average daily flow through the entire sewerage system. The daily flow during the period of sampling varied from a low of 13.7 million gallons on Sunday to a high of 15.3 million gallons on Friday.

Minor Discharges

There are four additional sewerage agencies in the Los Angeles Metropolitan Area that discharge comparatively small quantities of waste water directly to the ocean or its tidal waters. The City of Seal Beach and Los Alamitos Naval Air Station discharge their waste water flows into the San Gabriel River channel. The United States Naval Ammunition and Net

Depot at Seal Beach discharges waste water into Anaheim Bay, and the Sunset Beach Sanitary District discharges waste water directly into the Pacific Ocean.

City of Seal Beach. This agency provides secondary treatment for its waste water flows. The average daily flow during the fiscal year 1954-55 was 0.27 million gallons per day. The monthly average rate of discharge for the same period varied from a low of 0.23 million gallons per day in April to a high of 0.31 million gallons per day in July.

Sunset Beach Sanitary District. This agency operates a primary treatment plant. No flow data were obtainable for the fiscal year 1954-55. However, it was estimated that an average of 0.1 million gallons per day was discharged from the plant during the above season.

Los Alamitos Naval Air Station. This agency operates a secondary treatment plant. The average daily flow for the fiscal year 1954-55 was 0.10 million gallons per day. Monthly average rate of discharge for the same period varied from a low of 0.09 million gallons per day in November to a high of 0.13 million gallons per day in August.

United States Naval Ammunition and Net Depot. This agency operates a primary type of treatment plant. The average daily flow for the fiscal year 1954-55 was 0.06 million gallons per day. The monthly average daily discharge for the same period varied from a low of 0.05 million gallons per day in January to a high of 0.07 million gallons per day in July.

Estimated Future Quantity of Waste Water Discharged to Ocean

The total discharge of waste water to the ocean from the Los Angeles Metropolitan Area during the 1954-55 and 1959-60 seasons was about 505,000 and 648,000 acre-feet, respectively. Since this discharge can be expected to increase, it is interesting to estimate the volume of waste water that would be discharged to the ocean under ultimate conditions of development in the area.

An estimate of the ultimate quantity of waste water can be derived by calculating the unconsumed residual expected under ultimate conditions. The unconsumed residual is the difference between the water applied and the water consumed in urban areas. The whole of this unconsumed residual might in theory become waste water, if an urban area is 100 percent sewered, no deep percolation of applied water occurred, and no water ran off through storm drains or natural watercourses. In practice, the theoretical maximum is diminished by deep percolation, the absence of sewers over a portion of the area, and runoff of applied water into storm drains.

To estimate that portion of the unconsumed residual which takes the form of waste water discharged to the ocean, the highly urbanized coastal plain area of Los Angeles County was selected as a guide. Calculations show that the present waste water discharge for the urban portion of this area was 90 percent of the present unconsumed residual. Therefore, assuming this value to be valid for ultimate conditions, it was used to estimate the total probable ultimate sewage flow from the Los Angeles Metropolitan Area.

Using the basic information on ultimate water requirements presented in State Water Resources Board Bulletin No. 2, and the assumption and procedures outlined above, it is estimated that the mean seasonal quantity of waste water discharged to the ocean from the Los Angeles Metropolitan Area under probable ultimate conditions of development, assuming no reclamation, will be 1,636,000 acre-feet per year. This discharge was computed as follows:

Total ultimate water requirement	2,670,000 acre-feet per year
Total estimated consumptive use	852,000 acre-feet per year
Unconsumed residual	1,818,000 acre-feet per year

Unconsumed residual multiplied by 90 percent equals the estimated ultimate waste water discharge to the ocean of 1,636,000 acre-feet per year.

It was assumed that under ultimate conditions the sewered area would be expanded to include most of the Los Angeles Metropolitan Area in addition to appreciable increases in population density of the areas presently sewered.

Comparatively, this estimate of the probable ultimate discharge of waste water to the ocean is about 2.5 times as much as the total discharge during the 1959-60 season.

Analyzing Waste Water

"... it is necessary to utilize waste waters of the best mineral quality ...."

CHAPTER IV. MINERAL QUALITY OF WASTE WATER FLOWS

This chapter presents the principal factors affecting mineral quality of waste water, criteria for suitability for reclamation, field surveys of waste water quality, and future conditions. Except when otherwise specified, conditions described are those existing during this investigation which was primarily conducted during 1955 and 1956.

The undesirable sanitary characteristics of waste water can be attenuated by known methods of treatment. The type and degree of treatment used is largely a matter of economics. The sanitary quality of waste water can be upgraded to meet the basic requirements of many beneficial uses by primary and secondary treatment. The cost of this treatment is a large factor in determining the economic feasibility of reclaiming water from sewage.

Such primary and secondary treatment, however, affects the mineral quality of waste water only to a minor extent. Demineralization of water is a field which has been given considerable attention in the past few years. The subject is discussed in more detail in Chapter VI. It is sufficient to note here that, under present conditions, a practical application of demineralization to the reclamation of water from wastes would be the demineralization of brackish waters by electrodialysis. However, this demineralization process requires an influent water of sanitary quality far exceeding the basic requirements of most beneficial uses. Upgrading the mineral quality of waste water, in addition to the sanitary quality, would more than double the treatment cost compared to the necessary improvement of the sanitary quality alone. The cost of reclaimed water could be greatly reduced if waste water flows which are already of satisfactory mineral quality for most beneficial uses were available for reclamation. Considerable data have therefore been collected to evaluate the mineral quality of waste water flows. The sanitary and bacteriological qualities have been evaluated only on a limited basis. Hereafter, reference is made only to the mineral or sanitary quality of sewage flows. Sanitary analyses refer to determinations of biochemical oxygen demand (B.O.D.), suspended and settleable solids, volatile dissolved solids, and grease. All other determinations are referred to as mineral analyses.

Plate 4 shows schematically quantity and quality of the flows in the four principal sewerage systems of the area. The quality of the waste water flows is represented by a color scheme superimposed on the flow diagram. The suitability of the various flows for reclamation is indicated by the color blue, green, and red, corresponding to classifications of suitable, marginal, and unsuitable, respectively. These classifications follow the mineral quality criteria for reclaimed water developed in a later section of this chapter. The classifications indicated on the diagram are based on concentrations of total dissolved solids and chlorides, and the diagram as a whole is considered only as a generalized picture.

Factors Affecting Mineral Quality of Waste Waters

The waste water flow occurring in sewers of the area consists of three components: waters carrying domestic wastes, waters carrying industrial wastes, and infiltration waters. The quantity and quality of each of these components are the factors affecting the quality of the whole resultant flow. The mineral quality of waters carrying domestic and industrial wastes is a composite of the water supplied to the sewered areas, the mineral pickup resulting from the domestic and industrial use, and the quality and quantity of water infiltrating into the sewerage system.

Mineral Quality of Water Supplies

The most significant factor affecting quality of waste waters in the Los Angeles Metropolitan Area is the quality of the water supplied to the area. As previously discussed, water in the area is obtained from three sources: local water, primarily ground water from wells; water imported from the Mono and Owens Basins through the Los Angeles Aqueduct; and water imported from the Colorado River through the Colorado River Aqueduct.

The ranges of total dissolved solids in water supplied to the sewered portions of the area of investigation are presented on Plate 16. The relationship of quality of supply water to the quality of waste water is shown by comparison of Plates 16 and 4, taking into consideration areas producing industrial wastes and areas of infiltration of waters with high mineral concentrations. These areas are described later in this chapter.

Local Water. Within the area of investigation the quality of ground water varies from area to area even within the same ground water basin. This variation in quality was noted prior to extensive utilization of the ground water supplies, and recent intensive development of the area has resulted in additional causes for variation of the ground water quality. Land disposal of various wastes, overfertilization of crops, and continued overdraft of ground water basins with accompanying saline intrusions have produced substantial changes in the quality of underground waters. Because of this variation, a detailed evaluation of ground water quality is beyond the scope of this investigation.

In general, the ground water of the area is of better quality than that received from the Colorado River. The total dissolved solids concentrations of the ground waters range from 200 parts per million to 1,000 parts per million, and waters of the most productive basins generally average less than 500 parts per million, which is the desired maximum limit for drinking water standards.

Because local surface supplies are relatively unimportant in the area, a discussion of the quality of these supplies has been omitted in this report. However, the quality of surface water is reflected in the quality of ground water since ground water is replenished, in large part, by deep percolation of stream flow.

Mono and Owens Basins Water. The average mineral quality of water imported from the Mono and Owens Basins during 1954-55 through the Los Angeles Aqueduct is presented in Table 4. During that year the Los Angeles Aqueduct supplied 300,800 acre-feet of water to the City of Los Angeles. This was about 70 percent of the water used within the city, and a major portion of this use occurred in the San Fernando Valley.

Colorado River Water. The quality of both the natural and softened Colorado River supply delivered by The Metropolitan Water District of Southern California to the Los Angeles Metropolitan Area is presented in Table 5. As of 1954-55, approximately 57 percent of the total quantity of Colorado River water delivered to the area was softened.

Table 6 gives a 15-year quality record of water imported to the area from the Colorado River from the 1945-46 season through the 1959-60 season for chloride, boron, sulfate, and total dissolved solids in both the natural and softened state.

TABLE 4

MINERAL ANALYSIS OF WATER FROM
THE LOS ANGELES AQUEDUCT DURING 1954-55*

(Average for year ending June 30, 1955)

Mineral constituent or property	Symbol	Concentration of mineral constituent, in parts per million, except as noted
Silica	SiO_2	22
Iron	Fe	0.03
Calcium	Ca	26
Magnesium	Mg	6
Sodium	Na	40
Potassium	K	5
Sulfate	SO_4	23
Chloride	Cl	19
Nitrate	NO_3	0.2
Boron	B	0.58
Fluoride	F	0.7
Aluminum	Al	0.08
Manganese	Mn	0.005
Total dissolved solids (calculated)	TDS	218
Total hardness	$CaCO_3$	89
Alkalinity	$CaCO_3$	128
Hydrogen ion concentration	pH	8.42**
Electrical conductivity	$ECx10^6$	347**
Temperature (average)		61°F

*Analysis by City of Los Angeles, Department of Water and Power, Sanitary Engineering Division.
**This value is in standard units for measurement of this property of water.

TABLE 5

MINERAL ANALYSES OF COLORADO RIVER WATER(36)
DELIVERED TO THE LOS ANGELES METROPOLITAN AREA
DURING 1954-55

(Average for year ending June 30, 1955)

Mineral constituent or property	Symbol	Concentration of mineral constituent, in parts per million, except as noted: Natural water	Softened water
Silica	SiO_2	9.8	9.9
Iron	Fe	Trace	Trace
Calcium	Ca	81	31
Magnesium	Mg	29.5	12
Sodium	Na	97	188
Potassium	K	4	4
Carbonate	CO_3	1	2
Bicarbonate	HCO_3	144	139
Sulfate	SO_4	292	292
Chloride	Cl	81	85
Nitrate	NO_3	0.8	0.6
Boron	B	0.16	0.16
Fluoride	F	0.3	0.3
Total dissolved solids	TDS	669	694
Hardness as $CaCO_3$			
Total		324	127
Carbonate		120	118
Noncarbonate		204	9
Free carbon dioxide	CO_2	1	0
Hydrogen ion concentration	pH	8.4*	8.5*
Electrical conductivity	$ECx10^6$	1,040*	1,115*

*This value is in standard units for measurement of this property of water.

Note: Samples taken from the F. E. Weymouth Softening and Filtration Plant.

TABLE 6

MINERAL ANALYSES OF COLORADO RIVER WATER
DELIVERED TO THE LOS ANGELES METROPOLITAN AREA
FROM 1945 THROUGH 1960

(Average for years 1945 to 1960)

Period	Concentration of mineral constituents in parts per million							
	Chloride		Boron		Sulfate		Total dissolved solids	
	Natural	Softened	Natural	Softened	Natural	Softened	Natural	Softened
1945-1946	92	99	0.1	0.1	345	345	757	744
1946-1947	91	98	0.1	0.1	333	333	737	724
1947-1948	90	99	0.1	0.1	325	328	728	732
1948-1949	85	95	0.1	0.1	314	316	701	740
1949-1950	79	84	0.1	0.1	295	296	666	693
1950-1951	79	83	0.1	0.1	290	290	661	692
1951-1952	80	83	0.1	0.1	286	286	652	668
1952-1953	77	81	0.16	0.16	277	277	631	659
1953-1954	75	79	0.13	0.13	276	276	632	651
1954-1955	81	85	0.16	0.16	292	292	669	694
1955-1956	98	104	0.17	0.17	342	342	766	799
1956-1957	109	114	0.16	0.16	364	364	815	836
1957-1958	100	106	0.13	0.13	323	323	738	771
1958-1959	72	77	0.09	0.09	269	269	617	634
1959-1960	74	78	0.11	0.11	263	263	609	629
AVERAGE	85	91	0.12	0.12	306	307	692	711

Note: Samples taken from the F. E. Weymouth Softening and Filtration Plant at La Verne.

Mineral Pickup Resulting from Domestic and Industrial Use and Infiltration Waters

The majority of the waste water flow in the sewerage systems of the Los Angeles Metropolitan Area is domestic sewage. The amount of increase in mineralization of a water supply resulting from its use for domestic purposes varies somewhat with area and the mineral content of the water supply. This increase in mineralization was studied by the University of California at Los Angeles in preparing a report on waste water reclamation and utilization for the California State Water Pollution Control Board. The results of that study are summarized in Table 7.

TABLE 7

NORMAL RANGE OF MINERAL PICKUP
IN DOMESTIC SEWAGE*

Mineral constituent or property	Normal range, in parts per million except as noted
Dissolved solids	100-300
Boron (B)	0.1-0.4
Percent Sodium	5-15**
Sodium (Na)	40-70
Potassium (K)	7-15
Magnesium (Ca CO_3)	15-40
Calcium (Ca CO_3)	15-40
Total Nitrogen (N)	20-40
Phosphate (PO_4)	20-40
Sulfate (SO_4)	15-30
Chloride (Cl)	20-50
Total Alkalinity (Ca CO_3)	100-150

*From chart 1-8 of State Water Pollution Control Board Publication No. 9 "Studies of Waste Water Reclamation and Utilization".
**In percent.

In some of the trunk sewers of the area, industrial waste discharges are the chief influence on the mineral quality of the waste waters. Large discharges of wastes such as oil field brines may result in continuous gross deterioration of the mineral quality of waste water. Smaller waste discharges during off-peak flow periods seriously impair the quality for a short period of time.

Waters infiltrate the sewers both from the surface and subsurface. During periods of storm runoff, surface waters enter sewers at manholes and from unlawful connections. Although these waters infiltrating from the surface are generally of good quality and may form a substantial part of the total waste water flow during periods of storm runoff, they are not of great significance because of the infrequency of storms in the Los Angeles Metropolitan

Area. In areas of high ground water, substantial quantities of subsurface water may infiltrate the sewer lines. This subsurface infiltration sometimes produces a significant effect, especially in coastal areas where the infiltrating waters may be highly saline.

Like the quantity of flow, the mineral quality of waste water varies within a 24-hour period. In normal domestic sewage flows, the maximum and minimum concentrations are generally related to the peak and low flows respectively. This variation is illustrated on Plates 7, 8, 9, and 10. Off-peak industrial waste discharges or infiltration of large quantities of saline water may disrupt this relationship. The effect of saline water intrusion is illustrated on Plate 11, where the high mineral concentrations occur during the low flow period.

Other Factors Affecting Quality of Waste Waters

The use of various products, such as plastics, fibers, medicinal chemicals, dyes, and synthetic detergents, previously unknown or little used, has increased appreciably during the past two decades, and will probably continue to increase in the future. Some of these products find their way into the waste water flows in varying amounts. In most instances these products are not detrimental to the reclamation of water since they can be removed by conventional sewage treatment processes or can be isolated from the main trunk sewers with a minimum of effort. A notable exception is the synthetic detergents present in most domestic and some industrial waste waters. Because of their wide spread use and because they are resistant to ordinary treatment processes and persist in waters percolating underground, a brief discussion is considered pertinent.

An American Water Works Association Task Group Report[21] has defined a number of terms pertaining to synthetic detergents. A "synthetic detergent" or "syndet" is a product containing surface-active agents plus builders. "Surface-active agents" or "surfactants" are organic compounds which exhibit cleansing properties plus stability towards hardness. Surface-active agents may be classified as anionic, cationic, or nonionic on the basis of their ionization in water. About 72 percent of the total synthetic detergent production during 1958 was of the anionic type, 25 percent nonionic, and 3 percent cationic.[32] Alkyl benzene sulfonate (ABS) is the most common of the anionic surfactants. The term "builders" applies to various additive organic and inorganic compounds that are intended to improve the detergent action.

Although the synthetic detergent industry actually started in 1932, it has had its major growth since 1948.[22] During 1948, synthetic detergents accounted for 16 percent of soap industry sales.[22] By June 1959, this ratio had increased to approximately 90 percent.[41]

The degree of removal of various synthetic detergents by the biological oxidation of sewage treatment differs widely with the particular surfactant. Alkyl benzene sulfonate is quite resistant to normal sewage treatment processes. Studies have shown that the maximum reduction of alkyl benzene sulfonate which may be expected of activated sludge sewage treatment plants as presently designed and operated is in the order of 55 to 60 percent.[2
Research is presently being conducted to evolve a practical method for destroying surfactants in waste water flows. One of the more promising methods being studied is the agitation of waste water to cause it to froth and subsequent disposal of the froth by burning.

The presence in waste water flow of synthetic detergents currently used by householders constitutes a major problem in any large scale-water reclamation project utilizing domestic sewage. Detergent manufacturers can alleviate the problem by altering the composition and properties of the detergents. This has been demonstrated in England.(16)

Waste Water Quality Criteria for Reclamation

In evaluating the mineral quality of waste water to test its suitability for reclamation, the first consideration should be the potential uses since each has its own criterion. Other factors to be considered include the relative quality and availability of other sources of water, and the maintenance of suitable concentrations of dissolved constituents if the reclaimed water is used for ground water recharge.

Although present public acceptance limits direct use of reclaimed water to a few selected markets, recharge of ground water basins with reclaimed water would bring about its indirect employment in all prevailing beneficial uses of ground water. For that reason, it is necessary to utilize waste waters of the best mineral quality available.

To develop a basis for determining suitability of sewage for reclamation, it was necessary to review criteria for all potentially beneficial uses, both consumptive and nonconsumptive. The following paragraphs summarize the results of this review.

Irrigated Agriculture Water Quality Criteria

The major criteria used as a guide to judge the suitability of water for irrigation are chloride concentrations, specific electrical conductance (presented as $EC \times 10^6$ at 25°C), boron concentration, and percent sodium.

Chlorides are present in nearly all waters. They are not necessary to plant growth, and in high concentrations cause subnormal growing rates and burning of leaves.

Electrical conductance indicates the total dissolved solids, and furnishes an approximate indication of the overall mineral quality of the water. For most waters, the total dissolved solids, measured in parts per million, may be approximated by multiplying the electrical conductance by 0.7. As the amount of dissolved salts in irrigation water increases, the crop yields are reduced until at high concentrations (the value depending on the plant, type of soil, climatological conditions, and amount of water applied) plant life is threatened.

Boron is never found in the free state but occurs in the form of borates or boric acid. This element is essential in minor amounts for the growth of many plants. It is, however, extremely toxic to most plants in higher concentrations. Limits of tolerance for most irrigated crops vary from 0.5 to 2.0 parts per million. Citrus crops, particularly lemons, are sensitive to boron in concentrations exceeding 0.5 parts per million.

The percent sodium, as reported in analyses, is 100 times the proportion of the sodium cation to the sum of calcium, magnesium, sodium and potassium cations, all expressed in equivalents per million. Water containing a high percent sodium has an adverse effect upon the physical structure of soils which contain clay by dispersing the soil colloids which in turn retards the movement of water and the leaching of salts, and makes the soils difficult to work. The effect of potassium in water is similar to that of sodium.

Because of the diverse climatological conditions, crops, soils, and irrigation practices in California, criteria which may be set up to establish the suitability of water for irrigation use must necessarily be of a general nature, and judgment must be used in application of these criteria to individual cases.

Based on results of studies by Dr. L. D. Doneen, Professor of Irrigation at the University of California at Davis, three general classes of irrigation water have been established:

Class 1   Excellent to Good. Regarded as safe and suitable for most plants under any condition of soil or climate.

Class 2   Good to Injurious. Regarded as possibly harmful for certain crops under certain conditions of soil or climate, particularly in the higher ranges of this class.

Class 3   Injurious to Unsatisfactory. Regarded as probably harmful to most crops and unsatisfactory for all but the most tolerant.

Limiting values for concentrations of total dissolved solids, chloride, and boron, electrical conductance, and percent sodium for these three classes of irrigation water have been established and are shown in the following tabulation:

	Class 1	Class 2	Class 3
Total dissolved solids	Less than 700 parts per million	700 to 2,000 parts per million	More than 2,000 parts per million
Electrical conductance $EC \times 10^6$	Less than 1,000 micromhos	1,000 to 3,000 micromhos	More than 3,000 micromhos
Chloride	Less than 5 milliequivalents per liter	5 to 10 milliequivalents per liter	More than 10 milliequivalents per liter

	Class 1	Class 2	Class 3
Chloride	Less than 175 parts per million	175 to 350 parts per million	More than 350 parts per million
Percent sodium	Less than 60 percent	60 to 75 percent	More than 75 percent
Boron	Less than 0.5 parts per million	0.5 to 2.0 parts per million	More than 2.0 parts per million

Industrial Water Quality Criteria

A standard of quality of water for industrial purposes is exceedingly difficult to ascertain. The varieties of industrial usage are so many that a single set of standards for chemical, physical, and bacterial requirements would be meaningless. The attempt made in Table 8 to assign approximate water quality requirements to general types of industries is, therefore, a very general one, and the quality limits should be considered flexible. Even criteri obtained for the industries mentioned are not conclusive for all constituents. Water used for industrial purposes must therefore be considered as a raw material to be treated, if necessary, by the industrial user to fit individual needs and requirements.

Municipal and Domestic Water Quality Criteria

Water used for drinking and culinary purposes should be clear, colorless, odorless, pleasant to the taste, and free from toxic salts. It should not contain excessive amounts of dissolved mineral solids, and must be free of pathogenic organisms. Probably the most widely used criteria in determining the suitability of a water for this use are the "United States Public Health Service Drinking Water Standards, 1946". Limits for mineral constituents in water are divided into mandatory requirements and recommended criteria. The mandatory limits are as follows:

Mineral constituent	Maximum concentration, in parts per million
Lead (Pb)	0.1
Fluoride (F)	1.5*
Arsenic (As)	0.5
Selenium (Se)	0.05
Hexavalent Chromium (Cr^{+6})	0.05

Nonmandatory, but recommended, limits are as follows:

Copper (Cu)	3.0
Iron (Fe) and manganese (Mn) together	0.3
Magnesium (Mg)	125
Zinc (Zn)	15
Chloride (Cl)	250
Sulfate (SO_4)	250
Phenolic compounds in terms of phenol	0.001
Total solids, desirable	500
permitted	1,000

* The California State Board of Public Health has specified maximum limitations for fluoride ion concentrations as follows:

Approximate mean annual temperature, in degrees F	Maximum mean monthly fluoride ion concentration, in parts per million
50 or less	1.5
60	1.0
70 or more	0.7

The relationship of infant methemoglobinemia to nitrates in water supply has led to recommendations that limitations be set for nitrates in drinking water. The California State Department of Public Health has recommended a tentative limit for domestic waters of 10 parts per million nitrate nitrogen (N), which is equivalent to 44 parts per million nitrate (NO_3). Any waters containing higher nitrate concentrations should be considered to be of questionable quality for domestic and municipal use.

TABLE 8

LIMITS OF MINERAL CONCENTRATIONS, PHYSICAL PROPERTIES, AND BACTERIAL QUALITY OF WATER FOR VARIOUS INDUSTRIAL USES

(Allowable limits, in parts per million except as noted)

Constituent or property	Boiler feed water,[a] boiler pressure in pounds per square inch: 0-150	150-250	250-400	Concrete mixing[ae]	Cooling water	Production of plastics[a]	Steel manufacturing[a]	Tanning operations[a]	Textile manufacturing[a]	Production of paper[a]: Groundwood[g]	Soda and sulfate pulp[h]
Total solids	3000-500[b]	2500-500[b]	1500-100[b]	--	--	200	--	--	--	--	--
pH value	8.0 minimum	8.4 minimum	9.0 minimum	high values desired	7 to 9[f]	--	6.8 to 7.0	6.0 to 8.0	--	--	--
Chlorides (Cl)	--	--	--	--	--	--	175	--	100	75	75
Iron (Fe)	--	--	--	--	0.5[a]	0.02	--	0.1 to 2.0	0.1 to 1.0	0.3	0.1
Manganese (Mn)	--	--	--	--	0.5[a]	0.02	--	0.1 to 0.2	0.05 to 1.0	0.1	0.05
Iron and Manganese (Fe + Mn)	--	--	--	--	0.5[a]	0.02	--	0.2	0.2 to 1.0	--	--
Suspended matter	--	--	--	--	--	--	25	--	--	--	--
Temperature, °F	--	--	--	--	--	--	75°F	--	--	--	--
Turbidity	20	10	5	--	50[a]	2	--	20	0.3 to 25	--	--
Color	80	40	5	--	--	2	--	10 to 100	5 to 70	30[j]	5[j]
Dissolved oxygen	1.4[c]	0.14[c]	0.0[c]	--	--	--	--	--	--	--	--
Hydrogen sulfide (H_2S)	5[d]	3[d]	0[d]	--	--	--	--	--	--	--	--
Total hardness ($CaCO_3$)	80	40	10	--	50[a]	--	50	50 to 513	50	200	100
Sulfate-carbonate ratio (ASME) ($Na_2SO_4 : Na_2CO_3$)	1:1	2:1	3:1	--	--	--	--	--	--	--	--
Aluminum oxide (Al_2O_3)	5	0.5	0.05	--	--	--	--	--	--	--	--
Silica (SiO_2)	40	20	5	--	--	--	--	--	--	--	--
Bicarbonate (HCO_3)	50[c]	30[c]	5[c]	--	--	--	--	--	200	--	--
Carbonate (CO_3)	200	100	40	--	--	--	--	--	--	--	--
Hydroxide (OH)	50	40	30	--	--	--	--	--	--	--	--
Oxygen consumed	15	10	4	--	--	--	--	--	8	--	--
Total dissolved solids	--	--	--	100 minimum	2500[f]	--	--	--	--	500	250

LIMITS OF MINERAL CONCENTRATIONS, PHYSICAL PROPERTIES,
AND BACTERIAL QUALITY OF WATER FOR VARIOUS INDUSTRIAL USES
(continued)

(Allowable limits, in parts per million except as noted)

Constituent or property	Boiler feed water,[a] boiler pressure in pounds per square inch			Concrete mixing[ae]	Cooling water	Production of plastics[a]	Steel manufacturing[a]	Tanning operations[a]	Textile manufacturing[a]	Production of paper[a]	
	0-150	150-250	250-400							Groundwood[g]	Soda and sulfate pulp[h]
Free carbon dioxide (CO_2)	--	--	--	20	--	--	--	--	--	10	10
Sulfite (SO_3)	--	--	--	25	--	--	--	--	--	--	--
5 day BOD	--	--	--	--	--	--	25	--	--	--	--
Corrosion potential	--	--	--	--	--	--	Low as possible	--	--	--	--
Alkalinity	--	--	--	--	--	--		128 to 135	--	150	75
Heavy metals	--	--	--	--	--	--	--	--	None	--	--
Calcium (Ca)	--	--	--	--	--	--	--	--	10	--	--
Magnesium (Mg)	--	--	--	--	--	--	--	--	5	--	--
Sulfate (SO_4)	--	--	--	--	--	--	--	--	100	--	--
Turbidity as SiO_2	--	--	--	--	--	--	--	--	--	50[k]	25[k]
Silica (Soluble as SiO_2)	--	--	--	--	--	--	--	--	--	50	20
Calcium hardness as $CaCO_3$	--	--	--	--	--	--	--	--	--	--	50
Magnesium hardness as $CaCO_3$	--	--	--	--	--	--	--	--	--	--	50

a. California State Water Pollution Control Board. "Water Quality Criteria". Publication No. 3. 1952.
b. Depends on design of boiler.
c. Limits applicable only to feed water entering boiler, not to original supply.
d. Except where odor in live steam would be objectionable.
e. Water considered good enough to drink is considered safe for concrete unless otherwise noted.
f. California State Water Pollution Control Board. "A Survey of Direct Utilization of Waste Waters". Publication No. 12. 1955.
g. Groundwood papers are coarse papers composed primarily of groundwood fibers such as used for newspapers, telephone directories, cheaper grades of catalogues, and pulp magazines.
h. Pulps produced by chemical cooking processes known as the soda process and the sulfate or kraft process are also known as alkaline pulps.
j. Color in platinum units.
k. Materials causing turbidity shall not be gritty.

Another criterion used to classify water for domestic and industrial uses is total hardness. The effect of hardness in water is primarily economic. Its presence inhibits lathering with soap and causes formation of scale in boilers and plumbing systems. Hardness is caused by compounds of calcium and magnesium, although other substances such as iron, manganese, aluminum, barium, silica, strontium, and free hydrogen contribute to the total effect. Total hardness is expressed as parts per million of calcium carbonate and waters are classified as follows: less than 100 parts per million, "soft"; 101 to 200 parts per million "moderately hard"; above 200 parts per million, "very hard".

Classification of Waste Water for Reclamation Purposes

General mineral quality criteria have been developed to judge the suitability of waste water for economic reclamation in the Los Angeles Metropolitan Area and are presented in Table 9.

TABLE 9

CLASSIFICATION OF THE MINERAL QUALITY OF SEWAGE FOR RECLAMATION PURPOSES

Constituent	Limiting values in parts per million		
	Suitable	Marginal	Unsuitable
Chlorides	Less than 200	200 to 350	More than 350
Chlorides plus sulfates	Less than 500	500 to 1,000	More than 1,000
Boron	Less than 2	2 to 3	More than 3
Total dissolved solids	Less than 1,000	1,000 to 2,000	More than 2,000

Waters classed as suitable, with respect to the constituents considered, can, for the most part, be used successfully for prevailing and anticipated beneficial uses; waters classed as unsuitable would, in general, not meet the requirements for normal beneficial uses. Should any one of the four factors fall in a lower class, the water is classified as the lower class. It must be recognized that these classifications are not all inclusive. Waste water classed as suitable or marginal by these classification criteria could be considered unacceptable for reclamation purposes by virtue of abnormal concentrations of other pollutants such as synthetic detergents, phenolic compounds, hexavalent chromium, or nitrates.

Classification of the sanitary quality of waste water is presented in Table 10, for purposes of comparative discussion in succeeding chapters. Again, should any one of the three factors fall within the lower class, the sewage is classified as the lower class.

TABLE 10

CLASSIFICATION OF THE SANITARY QUALITY OF WASTE WATER

Constituent	Concentration of constituent, in parts per million		
	Weak	Medium	Strong
Biochemical oxygen demand 5 day, 20°C(37)	Less than 150	125 to 225	More than 200
Suspended solids (37)	Less than 175	150 to 250	More than 225
Grease or fats (2)	0	20	40

Field Survey of Waste Water Quality

As discussed in Chapter II, a major effort in this investigation was a sampling and flow measurement program conducted during 1955 at 19 stations along the four major sewerage systems within the Los Angeles Metropolitan Area. The method and frequency of sampling at these stations were also discussed in that chapter. The locations of these 19 stations were described in detail in Chapter III, together with data on quantity of flow past each of the stations. The results of the sampling program are discussed hereinafter.

City of Los Angeles

The ocean disposal of waste water from the City of Los Angeles through the Hyperion Treatment Plant constituted about 54 percent of the total discharge to the ocean from the Los Angeles Metropolitan Area during 1954-55. This waste water was generally suitable for reclamation according to the reclamation criteria. The Hyperion discharge is of substantially better mineral quality than any of the other three principal ocean discharges of waste water from the area. The discharge from the Terminal Island Treatment Plant is unsuitable according to the reclamation criteria.

As discussed in Chapter II, 13 sampling stations were established along the two sewerage systems belonging to the City of Los Angeles, 12 of which were in the system which discharges to Hyperion Treatment Plant. Two stations were established at the Valley Settling Basin, six on main trunk sewers upstream from the Hyperion Treatment Plant, one at the Venice Pumping Plant, three at the Hyperion Treatment Plant, and one at the Terminal Island Treatment Plant. Complete mineral analyses of samples obtained at these sampling stations are presented in Table E-1, Appendix E. Trace metal, grease, and sanitary analyses and determinations of biochemical oxygen demand of samples obtained at these sampling stations are also presented in Tables E-2, E-3, E-4, and E-5, Appendix E.

In about half of the cases, the mineral analyses of the weekly composite samples are not commensurate with the analyses of daily composite samples from the same stations, even though the weekly samples were prepared by compositing the daily samples. These anomalies may be noted in the graphical presentation of mineral analyses on Plate 17 and demonstrate the effects of storage and biochemical activity. Therefore, the averages of mineral analyses of daily composite samples, weighted in proportion to flow, are considered more reliable than the analyses of the weekly composites and are used in the following discussion of quality of waste water for comparison with reclamation quality criteria. Table 11 summarizes the mineral analyses of the daily composite samples and presents the maximum, minimum, and average (weighted by flow) of each constituent analyzed.

Although waste water flows in the system which discharges through the Hyperion Treatment Plant are generally suitable according to the reclamation criteria for mineral quality, studies were made to determine the extent to which the mineral quality of water reclaimed from these waste waters could be improved by rejecting flows of high mineral concentrations. For the selected stations, flows with electrical conductance exceeding certain values were assumed to be rejected, and the average electrical conductance of the remaining flow was computed. The results of these studies are tabulated in Table E-6, Appendix E, and are discussed by individual stations in the following paragraphs.

Valley Settling Basin. During the week of sampling, flow through the Valley Settling Basin amounted to about three percent of the total flow through the Hyperion Treatment Plant. The influent varied from a weak to a strong waste water with suspended solids averaging 171 parts per million, and grease ranging from 17 to 42 parts per million. However, monthly averages of biochemical oxygen demand and suspended solids indicated a strong waste water, with ranges of 282 to 398 parts per million biochemical oxygen demand, and 428 to 767 parts per million suspended solids for the period November 1954 through June 1955. Treatment at the Valley Settling Basin Plant during the week of sampling resulted in 75 percent removal of the suspended solids, and 25 to 89 percent removal of grease. In addition, the monthly averages for

TABLE 11

SUMMARY OF SANITARY AND MINERAL ANALYSES OF DAILY COMPOSITE SAMPLES FROM THE CITY OF LOS ANGELES SEWERAGE SYSTEM

	$EC \times 10^6$ at 25° C	Constituents in parts per million																					
		Ca	Mg	Na	K	NH_4	CO_3	HCO_3	SO_4	Cl	NO_3	F	NO_2	PO_4	B	SiO_2	Total dissolved solids	Settleable solids	Suspended solids	Fixed solids	Organic nitrogen	Total hardness as $CaCO_3$	Percent sodium
Valley Settling Basin Influent, June 17 through June 23, 1955																							
Minimum	1070	30	16	110	17	31	0	387	30	74	2	1.6	0	42	0.95	12	628	1	38	480	0	160	52
Maximum	1170	50	21	130	20	44	0	441	130	136	4	1.8	0	63	1.50	20	711	6	255	551	5	195	60
Average weighted by flow	1130	39	18	123	19	36	0	411	81	97	3	1.7	0	50	1.24	17	666	5	171	508	1	172	57
Valley Settling Basin Effluent, June 17 through June 23, 1955																							
Minimum	1165	48	16	108	16	23	0	180	252	93	1	0.4	0	0	1.00	8	640	0	19	565	0	185	51
Maximum	1230	56	23	132	18	40	0	206	264	120	25	0.6	0	1	1.25	14	709	10	85	622	4	234	57
Average weighted by flow	1200	53	18	126	17	30	0	187	259	109	14	0.5	0	0*	1.10	10	693	3	43	601	1	211	54
Glendale Outfall Sewer at Partridge Avenue, June 17 through June 23, 1955																							
Minimum	1035	44	16	103	14	27	0	358	97	83	1	0.8	0	20	0.70	13	554	0	36	482	0	195	51
Maximum	1190	52	26	134	17	40	0	435	116	116	9	1.6	0	35	1.15	20	660	10	176	569	5	230	56
Average weighted by flow	1140	50	21	120	16	35	0	389	109	103	4	1.1	0	24	0.96	18	624	5	113	537	2	209	53
Outfall Sewer at Fourth Street and Mission Road, June 17 through June 23, 1955																							
Minimum	1140	50	17	117	15	25	0	372	86	96	1	1.0	0	22	0.65	12	640	0	28	544	0	210	52
Maximum	1360	58	25	156	19	33	0	430	142	156	4	1.3	0	37	0.90	22	766	9	246	652	4	239	59
Average weighted by flow	1280	54	21	144	17	28	0	401	116	133	2	1.1	0	28	0.78	18	736	4	147	618	2	223	54

SUMMARY OF SANITARY AND MINERAL ANALYSES OF DAILY COMPOSITE SAMPLES FROM THE CITY OF LOS ANGELES SEWERAGE SYSTEM
(continued)

	$EC \times 10^6$ at 25° C	Constituents in parts per million																			Per-cent sodium
		Ca	Mg	Na	K	NH_4	CO_3	HCO_3	SO_4	Cl	NO_3	F	NO_2	PO_4	B	SiO_2	Total dissolved solids	Settleable solids	Suspended solids	Fixed solids	Organic nitrogen	Total hardness as $CaCO_3$	
Outfall Sewer at Eighth Street and Mission Road, June 17 through June 23, 1955																						
Minimum	1040	49	15	118	15	0	0	157	133	99	20	0.8	13	8	0.60	18	672	5	83	567	0	216	52
Maximum	1270	62	24	171	17	24	0	338	165	156	133	1.4	27	25	1.10	18	816	16	198	702	1	230	61
Average weighted by flow	1180	54	20	144	16	5	0	208	150	130	92	1.0	22	17	0.86	18	735	8	135	635	0*	220	56
North Outfall Sewer at Manhole No. 1, June 24 through June 30, 1955																						
Minimum	1190	53	19	139	14	0	0	179	124	143	2	1.1	0	25	0.98	12	719	5	107	615	0	221	55
Maximum	1460	58	22	177	15	59	0	412	146	181	110	1.4	16	30	1.39	18	804	7	183	742	0	235	62
Average weighted by flow	1390	56	21	167	15	27	0	309	139	164	49	1.2	7	28	1.26	16	775	6	149	699	0	227	60
Central Outfall Sewer near Florence Avenue and Ash Avenue, June 24 through June 30, 1955																						
Minimum	1250	49	18	129	14	6	0	325	134	121	0	1.0	0	20	0.90	12	690	4	102	616	0	214	53
Maximum	1575	65	22	200	18	36	0	458	159	204	25	1.7	5	28	1.28	20	887	10	353	824	0	244	62
Average weighted by flow	1450	59	20	177	16	28	0	398	148	165	14	1.3	2	26	1.11	15	790	6	233	716	0	232	60
Hyperion Sewage Treatment Plant Influent, June 24 through June 30, 1955																						
Minimum	1420	16	21	192	18	22	0	262	71	236	6	0.9	0	10	0.83	14	729	—	—	615	0	132	66
Maximum	1610	49	29	218	19	32	0	366	134	258	20	1.2	0	20	1.32	16	912	—	—	794	1	210	75
Average weighted by flow	1550	35	24	211	18	26	0	334	118	247	12	1.1	0	15	1.11	15	853	—	—	738	1	188	68

SUMMARY OF SANITARY AND MINERAL ANALYSES OF DAILY COMPOSITE SAMPLES FROM THE CITY OF LOS ANGELES SEWERAGE SYSTEM
(continued)

	ECx10^6 at 25° C	Ca	Mg	Na	K	NH_4	CO_3	HCO_3	SO_4	Cl	NO_3	F	NO_2	PO_4	B	SiO_2	Total dissolved solids	Settleable solids	Suspended solids	Fixed solids	Organic nitrogen	Total hardness as $CaCO_3$	Percent sodium
		Constituents in parts per million																					
Hyperion Sewage Treatment Plant Effluent from Primary Clarifiers, June 24 through June 30, 1955																							
Minimum	1500	47	27	193	.6	35	0	389	127	228	0	1.0	0	23	0.84	12	867	--	--	789	0	239	60
Maximum	1740	54	31	222	19	43	0	430	161	246	5	1.2	1	30	1.25	20	945	--	--	875	1	258	64
Average weighted by flow	1680	51	29	212	18	38	0	407	150	238	2	1.1	0*	26	1.14	18	907	--	--	836	0*	246	63
Hyperion Sewage Treatment Plant Final Effluent, June 24 through June 30, 1955																							
Minimum	1600	46	23	196	15	23	0	361	147	227	0	1.0	0	12	0.75	14	840	--	--	793	0	232	62
Maximum	1680	55	31	226	18	28	0	374	164	244	8	1.6	1	17	1.05	20	926	--	--	854	0	241	66
Average weighted by flow	1650	50	26	212	16	26	0	367	155	237	5	1.4	0*	15	0.89	17	900	--	--	832	0	235	64
Venice Pumping Plant Influent, June 24 through June 30, 1955																							
Minimum	5740	77	106	901	41	18	0	316	382	1440	4	0.9	0	10	1.10	9	3356	--	--	2927	0	635	71
Maximum	6440	94	148	1010	47	39	0	400	406	1718	74	1.2	5	25	1.40	18	3807	--	--	3319	0	844	74
Average weighted by flow	5940	83	116	930	43	33	0	376	392	1512	20	1.0	2	19	1.23	15	3495	--	--	3081	0	688	73
Terminal Island Sewage Treatment Plant Effluent, June 24 through June 30, 1955																							
Minimum	4020	52	57	635	34	0	0	117	166	990	60	1.0	9	5	2.10	16	2280	0	9	2081	0	412	75
Maximum	4420	79	73	690	36	29	0	302	245	1067	145	1.5	30	35	2.30	20	2561	2	53	2292	1	463	76
Average weighted by flow	4140	64	65	657	34	11	0	199	219	1012	114	1.3	18	28	2.22	18	2430	1	31	2163	0*	428	75

*Less than one ppm.

suspended solids and biochemical oxygen demand of influent to and effluent from the plant showed a removal efficiency of 89 to 97 percent for suspended solids, and 52 to 73 percent for biochemical oxygen demand.

Average concentrations computed from the analyses of the daily composite samples, show a change from a predominately sodium-calcium bicarbonate type of waste water at the influent to a sodium-calcium sulfate-chloride type at the effluent. This change in predominant anions from the influent to the effluent may be attributed to the addition of aluminum sulfate used as a flocculant at the Valley Settling Basin.

Analyses of the more mineralized influent flows (high electrical conductance and/or chloride samples) showed no consistency in mineral character. The mineral character of the daily composite samples of the influent varied, in order of abundance, from a sodium-calcium bicarbonate type to a sodium-ammonium bicarbonate type. Analyses of the daily composite samples of the effluent indicated that the flows were principally sodium-calcium sulfate-bicarbonate, but included sodium sulfate-chloride type waters.

The average concentrations of 693 parts per million total dissolved solids, 109 parts per million chloride, and 368 parts per million chlorides plus sulfates, and 1.10 parts per million boron in the effluent during the period of sampling were within suitable limits for reclamation.

On Plate 6 it may be noted that the range of hourly measurements of electrical conductance for the week of sampling varied from a minimum of 870 to a maximum of 1,450 micromhos for the influent. The average daily values weighted by flow for the same period ranged from 1,020 to 1,120 micromhos. For the effluent, the hourly variations ranged from 1,000 to 1,410 micromhos, and the average daily values ranged from 1,120 to 1,190 micromhos. The average daily chloride concentrations varied from 74 to 100 parts per million for the influent and 82 to 110 parts per million for the effluent.

Studies were made of improving the mineral quality of the effluent from Valley Settling Basin that would result if the more mineralized flows were rejected. If flows with electrical conductance exceeding 1,220 micromhos had been rejected, the resulting daily average electrical conductance would have varied from 1,110 micromhos to 1,170 micromhos, with a weekly average of 1,140 micromhos (one percent reduction from that of normal flow) and a weekly reduction in quantity of discharge of 19 percent from the actual flow. Rejecting flows with an electrical conductance over 1,190 micromhos would have resulted in daily averages ranging from 1,090 to 1,150 micromhos, with a weekly average of 1,120 micromhos (three percent reduction from that of normal flow) and a weekly reduction in quantity of effluent discharge of 31 percent. At this station the rejection of the more mineralized flows would not achieve a reasonable improvement in mineral quality without the loss of a large proportion of the flow.

Analyses of a limited number of grab samples collected in May 1960 and a cursory review of the changes in the sewered area and sewerage system indicate that there has been little change since 1955 in mineral quality of waste water originating in the San Fernando Valley. As will be discussed in Chapter VII, waste water from the San Fernando Valley now flows through two trunk sewers, the Glendale Outfall Sewer and the San Fernando-La Cienega Relief Sewer. The mineral quality of flow in the latter trunk sewer is somewhat better than in the former, however, flow in the Glendale Outfall Sewer near the Valley Settling Basin is still suitable according to the reclamation criteria.

Glendale Outfall Sewer at Partridge Avenue. This sampling station was established downstream of the Valley Settling Basin at a point on the Glendale Outfall Sewer where it carries nearly the entire waste water flow from the San Fernando Valley. The flow past this station constituted about 20 percent of the flow through the Hyperion Treatment Plant.

During the week of sampling, flows at this station varied from a weak to strong waste water, with suspended solids averaging 113 parts per million, biochemical oxygen demand ranging from 200 to 350 parts per million, and grease ranging from 2 to 34 parts per million.

Analyses of the more mineralized flows show that they were principally sodium-ammonium bicarbonate in character, but included sodium bicarbonate, sodium-calcium bicarbonate, sodium-calcium bicarbonate-sulfate, and sodium-calcium bicarbonate-chloride types. The analyses of the daily composite samples, however, consistently indicated a sodium-calcium bicarbonate type of water.

According to the reclamation criteria, these waste water flows were suitable for reclamation, with average concentrations of 624 parts per million total dissolved solids, 103 parts per million chloride, 212 parts per million chloride plus sulfate, and 0.96 parts per million boron.

From Plate 7 it may be noted that the hourly electrical conductance for the week varied from a minimum of 870 micromhos to a maximum of 1,420 micromhos. The average daily values for the same period ranged from 1,030 to 1,080 micromhos. The average daily chloride concentrations varied from 79 to 101 parts per million.

The mineral quality of a possible diversion from this station would be slightly improved if the more mineralized flows were bypassed, but only at the expense of rejecting a large proportion of the flow. If flows with electrical conductance exceeding 1,100 micromhos had been rejected, the resulting daily average electrical conductance would have varied from 990 to 1,030 micromhos with a weekly average of 1,010 micromhos (four percent lower than that of normal flow), and a weekly flow reduction of 27 percent. Rejecting flows with an electrical conductivity over 1,050 micromhos would have resulted in daily averages ranging from 960 to 1,030 micromhos, with a weekly average of 1,000 micromhos (five percent lower than that of normal flow), and a weekly flow reduction of 46 percent.

Glendale Outfall Sewer at Mission Road. As noted in Chapter III, flow in this trunk sewer was sampled in this area at two stations at Fourth Street and Mission Road and at Eighth Street and Mission Road. During the sampling program, the flow at Fourth Street and Mission Road constituted approximately 82 percent of the flow at Eighth Street and Mission Road, and 19 percent of the total flow through the Hyperion Treatment Plant.

During the week of sampling, the flow at the Fourth Street and Mission Road station varied from a weak to a strong waste water with suspended solids averaging 147 parts per million, biochemical oxygen demand ranging from 150 to 290 parts per million, and grease ranging from 12 to 42 parts per million. On the basis of fewer samples, the flow at the Eighth Street and Mission Road station varied from a weak to a strong waste water, with suspended solids averaging 135 parts per million, biochemical oxygen demand ranging from 250 to 400 parts per million, and one sample indicating 6 parts per million grease.

Analyses of the more mineralized flows show that they were principally sodium bicarbonate and sodium bicarbonate-chloride in character, but also included sodium-calcium bicarbonate, sodium-calcium bicarbonate-chloride, and sodium chloride-bicarbonate type waters. Analyses of the daily samples showed that the flows were principally sodium-calcium bicarbonate and sodium bicarbonate in character. An average of the analyses of the daily composite samples indicates a sodium-calcium bicarbonate type water. Although sodium still was the predominant cation in the flows at Eighth Street and Mission Road, that was a decrease in the concentration of bicarbonate ions which made the flows a sodium chloride-bicarbonate type. It is interesting to note that the decrease in bicarbonate ions was marked by average net increases of 90 parts per million nitrate ions and 34 parts per million sulfate ions, with no apparent change in chloride concentration. This phenomenon reflects the effect of storage on the samples from the Eighth Street and Mission Road Station between the time the samples were collected and the time they were analyzed.

According to the reclamation criteria, the flows at Fourth Street and Mission Road were suitable for reclamation with 736 parts per million total dissolved solids, 133 parts per million chloride, 249 parts per million chloride plus sulfate, and 0.78 parts per million boron.

It may be seen from Plate 8 that the hourly measurements of electrical conductance for the week varied from a minimum of 942 to a maximum of 2,079 micromhos. Average daily values ranged from 1,110 to 1,250 micromhos. The average daily chloride concentrations varied from 93 to 140 parts per million.

The mineral quality of a possible diversion from this station would be improved if the more mineralized flows were bypassed, but again only by rejecting a large proportion of the total flow. If flows with an electrical conductance exceeding 1,300 micromhos were rejected, the resulting daily average electrical conductance would have varied from 1,110 to 1,180 micromhos with a weekly average of 1,140 micromhos (six percent reduction from that of normal flow), and a weekly flow reduction of 22 percent. Rejecting flows of over 1,200 micromhos of electrical conductance would have resulted in daily averages ranging from 1,040 to 1,120 micromhos, and a weekly average of 1,090 micromhos (ten percent reduction from that of normal flow), and a weekly flow reduction of 40 percent.

Several grab samples were obtained from the sewer at Fourth Street and Mission Road during May 1960 to determine what changes in mineral quality of waste water have occurred since 1955. Analyses of these samples indicate that concentrations of many minerals have increased; however, the waste water is still suitable for reclamation according to the criteria noted in Table 9.

North Outfall Sewer. During the sampling program flows through the North Outfall Sewer at Manhole No. 1 constituted about 80 percent of the flow through the Hyperion Treatment Plant. Flows at Manhole No. 1 varied from a weak to a strong waste water with suspended solids averaging 149 parts per million, biochemical oxygen demand ranging from 180 to 315 parts per million, and grease ranging from 5 to 19 parts per million.

Analyses of the more mineralized flows indicated that they were principally sodium bicarbonate-chloride in character, but included sodium chloride-bicarbonate and sodium-calcium bicarbonate-chloride type waters. Likewise, analyses of the daily composite samples indicated that the flows were predominately sodium bicarbonate-chloride and sodium chloride-bicarbonate in character.

The concentrations of 775 parts per million total dissolved solids, 164 parts per million chlorides, 303 parts per million chlorides plus sulfates, and 1.26 parts per million boron made these flows suitable for reclamation.

On Plate 9 it may be seen that the hourly electrical conductance for the week varied from a minimum of 1,050 to a maximum of 1,500 micromhos. Average daily values ranged from 1,190 to 1,300 micromhos. The daily average chloride concentrations varied from 136 to 172 parts per million.

The mineral quality of a possible diversion from this station would be only slightly improved if the more mineralized flows were bypassed resulting in a large reduction of usable flow. If flows with an electrical conductance exceeding 1,300 micromhos had been rejected, the resulting daily average electrical conductance would have varied from 1,180 to 1,220 micromhos with a weekly average of 1,200 micromhos (three percent reduction from that of normal flow) and a weekly flow reduction of 21 percent. Rejecting flows with an electrical conductance over 1,200 micromhos would have resulted in a daily average conductance ranging from 730 to 1,180 micromhos with a weekly average of 1,090 micromhos (12 percent reduction from that of normal flow), and a weekly flow reduction of 60 percent.

Central Outfall Sewer. A sampling station near Florence and Ash Avenues in Inglewood was established to determine the quality of sewage in the Central Outfall Sewer upstream of the junction with the North Outfall Sewer. Flows at this station represented 14 percent of the flow to the Hyperion Treatment Plant.

During the week of sampling, the flows at this station varied from a weak to strong waste water with suspended solids averaging 233 parts per million, biochemical oxygen demand ranging from 170 to 410 parts per million, and grease ranging from 5 to 16 parts per million.

Analyses of the more mineralized flows indicated that they were principally sodium chloride-bicarbonate in character, but also included sodium chloride and sodium bicarbonate-chloride type waters. The daily composite samples were predominately sodium bicarbonate-chloride in character.

The weekly average concentrations of 790 parts per million dissolved solids, 165 parts per million chloride, 313 parts per million chloride plus sulfate, and 1.11 parts per million boron were all within suitable limits for reclamation.

From Plate 10 it may be noted that the hourly measured electrical conductance for the week varied from a minimum of 952 to a maximum of 2,020 micromhos. Average daily values ranged from 1,160 to 1,350 micromhos. The average daily chloride concentrations varied from 113 to 198 parts per million.

The mineral quality of a possible diversion from this station would be slightly improved if the more mineralized flows were bypassed, but only after a large reduction in the total usable flow. If flows with an electrical conductance exceeding 1,400 micromhos had been rejected, the resulting daily average electrical conductance would have varied from 1,160 to 1,250 micromhos with a weekly average of 1,210 micromhos (six percent reduction from that of normal flow), and a weekly flow reduction of 22 percent. Rejecting flows with an electrical conductance exceeding 1,300 micromhos would have resulted in a daily average conductance ranging from 1,060 to 1,180 micromhos, with a weekly average of 1,150 micromhos (11 percent reduction from normal flow), and a weekly flow reduction of 46 percent.

Venice Pumping Plant. The waste water from Venice Pumping Plant constituted about six percent of the total inflow to Hyperion.

The mineral quality of the Venice Pumping Plant discharge is markedly affected by the infiltration of ocean water into the sewerage system. As a result, the discharge from the pumping plant is consistently sodium chloride in character. This flow is unsuitable for reclamation according to the reclamation criteria since it contained an average value of 3,500 parts per million total dissolved solids, 1,510 parts per million chloride, 1,904 parts per million chloride plus sulfate, and 1.23 parts per million boron. Variations of electrical conductance and chloride ion concentration during the week are shown on Plate 11.

Hyperion Treatment Plant. The influent, effluent from the primary clarifiers, and the final effluent of the Hyperion Treatment Plant were sampled every hour for a period of one week.

During the fiscal year 1953-54, the influent varied from a medium to a strong waste water, with monthly average values ranging from 184 to 278 parts per million biochemical oxygen demand, and 253 to 377 parts per million suspended solids. Reductions of 10 to 42 percent in biochemical oxygen demand, and 35 to 53 percent suspended solids were effected by the primary treatment. The average monthly overall efficiency of the plant was 66 to 80 percent for biochemical oxygen demand removal and 74 to 83 percent for suspended solids removal.

Analyses of the more mineralized influent consistently showed a sodium chloride type water. Analyses of daily composite samples consistently indicated a sodium chloride-bicarbonate type water for both the influent and final effluent. Analyses of the daily composite samples of the primary effluent indicated that the flow was principally sodium chloride-bicarbonate, but varied to a sodium bicarbonate-chloride type water.

During the week of sampling, the final effluent from the Hyperion Treatment Plant contained an average of 900 parts per million total dissolved solids, 392 parts per million chloride plus sulfate, and 0.89 parts per million boron. Although these constituents were within the suitable limits for reclamation, the chloride concentration of 237 parts per million made the final effluent suitable to marginal for reclamation.

Plate 12 shows hourly measured values of electrical conductance during the week of sampling. Fluctuations of the electrical conductance and chloride concentration curves are dampened from the influent to final effluent as the sewage flows become more uniform through mixing in the plant.

The mineral quality of a possible diversion from this station would not be improved to any material extent if the more mineralized flows were bypassed without a great reduction in the total usable flow. If the final effluent flows with an electrical conductance exceeding 1,600 had been rejected, the resulting daily average electrical conductance would have varied from 1,460 to 1,550 micromhos, with a weekly average of 1,490 micromhos (about one-half percent reduction from that of normal flow), and a weekly flow reduction of seven percent. Rejecting flows of over 1,550 micromhos would have resulted in daily averages ranging from 1,430 to 1,510 micromhos, with an overall average of 1,470 micromhos (two percent reduction from that of normal flow), and a weekly flow reduction of 29 percent.

The quality of influent to the Hyperion Treatment Plant could be improved by excluding the flow from the Venice sewer. This would have resulted in a six percent reduction in quantity of influent, and reduction of 21 percent in total dissolved solids, 35 percent in chlorides, and 29 percent in chlorides plus sulfates. Computations of the effect of preventing flow from the Venice sewer from mixing with other flow through the Hyperion Treatment Plant are presented in Table 12.

TABLE 12

IMPROVEMENT OF MINERAL QUALITY OF HYPERION TREATMENT PLANT INFLUENT BY EXCLUDING FLOW FROM THE VENICE SEWER

Designation of flow	Average flow, in cubic feet per second	Constituents, in parts per million: Total dissolved solids	Chloride	Chloride plus sulfate	Boron
Hyperion Treatment Plant Influent	361	853	247	365	1.1
Flow through the Venice Pumping Plant	23	3,500	1,510	1,900	1.2
Hyperion Treatment Plant Influent less flow through the Venice Pumping Plant[a]	338	673	161	260	1.1
Flow from the North Outfall and Central Outfall Sewers[a]	342	772	164	304	1.2

a. Calculated

The mineral quality of the final effluent from the secondary facilities at Hyperion Treatment Plant has not changed appreciably in the five years since the sampling program was conducted even though the operation of the plant was modified as will be discussed in Chapter VII. Analysis of one 24-hour composite sample of final effluent indicates a significant reduction of chloride ion concentration, possibly resulting from the elimination from the effluent of a large percentage of the flow from the Venice Trunk Sewer. The effluent is now classified as suitable for reclamation.

Terminal Island. During the period of sampling, the effluent from this plant contained suspended solids averaging 31 parts per million, and grease varying from two to eight parts per million. As a result of sea-water intrusion into the sewers discharging to this plant, samples consistently indicated water of sodium chloride type. Average values of 2,430 parts per million total dissolved solids, 1,012 parts per million chloride, 1,231 parts per million chloride plus sulfate, and 2.2 parts per million boron rendered these waste water flows unsuitable for reclamation according to the reclamation criteria. Variations of electrical conductance and chloride ion concentration during the week of sampling are shown on Plate 13.

County Sanitation Districts of Los Angeles County

The waste water discharged through the districts' outfall at Whites Point constituted 40 percent of the total ocean disposal of waste water from the Los Angeles Metropolitan Area during 1954-55.

The mineral quality of the flow entering the Joint Disposal Plant of the County Sanitation Districts of Los Angeles County is considerably poorer than the flow entering the Hyperion Treatment Plant of the City of Los Angeles. A major portion of the sewered area served by the districts' outfall is supplied with water containing more than 300 parts per million total dissolved solids, while water supplied to the City of Los Angeles generally contained less than 300 parts per million total dissolved solids. Moreover, there are a relatively large number of mineralized industrial waste discharges to the County Sanitation Districts' sewerage system. There are, however, upstream points in the districts' system where the mineral quality of the waste water flow is relatively unaffected by industrial waste discharges.

To aid in the selection of sampling stations, a preliminary grab sampling program was first conducted. On the basis of the results from this program and data on the major industrial waste discharges to the County Sanitation Districts' system, four sampling points were selected for a week-long sampling program. The locations of these stations are shown on Plate 2.

Analyses of grab and daily continuous samples from these four stations in the County Sanitation Districts' system are presented in Table E-7, Appendix E. The analyses indicate that the electrical conductance and chlorides increased together. The effect of industrial waste discharges was observed to vary between different stations.

Spectrographic analyses of weekly composite samples from each station are presented in Table E-8, Appendix E. Since they are qualitative determinations, the values of selected constituents were not given as much weight as those of the trace metals analyses, presented in Table E-2 and were merely used as a check.

Complete mineral analyses are presented in Table E-9, Appendix E, and analyses for biochemical oxygen demand and phenol are presented in Table E-10. Hydrographs showing the temporal variations in selected flows appear on Plate 14, and pictorial comparisons of selected mineral constituents in the daily continuous samples are presented in Plate 18. A summary of the maximum, minimum, and average (weighted by flow) of each mineral constituent in the daily continuous samples is presented in Table 13.

Joint Outfall "B". This outfall serves the San Gabriel Valley area. The sampling station on this trunk sewer is at the intersection of Loma Avenue and Klingerman Street near Whittier Narrows. Flow past this station amounts to 17 percent of the total flow into the Districts' Joint Disposal Plant.

TABLE 13

SUMMARY OF SANITARY AND MINERAL ANALYSES OF DAILY SAMPLES FROM THE COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY SEWERAGE SYSTEM

	$ECx10^6$ at 25° C	Constituents in parts per million																			
		Ca	Mg	Na	K	NH_4	CO_3	HCO_3	SO_4	Cl	NO_3	F	NO_2	PO_4	B	SiO_2	Total dissolved solids	Settleable solids	Suspended solids	Fixed solids	Organic nitrogen	Total hardness as $CaCO_3$	Percent sodium
Joint Outfall "B" Loma Avenue and Klingerman Street, December 6 through December 12, 1955																							
Minimum	1210	30	12	142	15	27	0	319	132	88	3	0.7	0	10	0.40	20	617	1	122	483	1	126	67
Maximum	1480	34	15	237	20	60	0	432	187	117	25	1.0	0	27	1.10	24	724	12	780	607	1	143	76
Average weighted by flow	1320	33	14	179	17	39	0	370	166	104	11	0.8	0	16	0.73	22	698	5	411	572	1	138	71
South Whittier Outfall South of Imperial Highway on Carmenita Road, December 6 through December 12, 1955																							
Minimum	1090	42	16	138	13	23	0	374	70	232	0	0.4	0	5	1.05	18	837	4	338	715	0	176	59
Maximum	1600	62	19	232	16	27	0	435	103	251	13	0.7	0	18	1.32	24	905	7	2402	781	3	227	72
Average weighted by flow	1510	51	17	207	15	25	0	404	87	246	9	0.6	0	13	1.16	20	888	5	979	752	1	199	67
Joint Outfall "G" Bort Street Extended West of Gale Avenue, December 6 through December 12, 1955																							
Minimum	1890	56	19	263	14	32	0	313	53	134	0	0.8	0	3	1.58	16	1198	4	252	985	0	240	65
Maximum	2390	76	27	338	34	49	0	363	667	186	15	4.8	0	17	2.37	28	1550	10	1394	1343	1	279	72
Average weighted by flow	2110	70	22	297	20	38	0	346	456	157	3	2.1	0	8	1.80	22	1360	7	690	1180	1	266	69
Joint Outfall "E" North of Greenleaf Drive on Alameda Street, December 6 through December 12, 1955																							
Minimum	1570	61	21	217	14	21	0	374	152	194	0	0.2	0	1	1.11	12	891	5	662	747	0	239	59
Maximum	2120	92	28	276	41	65	0	553	243	304	6	1.2	0	15	2.24	24	1261	13	1326	1103	2	328	65
Average weighted by flow	1930	74	24	248	28	30	0	428	197	271	2	0.9	0	5	1.56	20	1150	10	1070	945	1	289	63

During the week of sampling, flows at this station varied from a weak to a strong waste water, with suspended solids averaging 411 parts per million, and biochemical oxygen demand ranging from 60 to 240 parts per million.

The predominant mineral constituents in these flows averaged from the analyses of the daily samples were sodium, bicarbonate, and sulfate. Analyses of daily samples indicated that the flows were principally sodium bicarbonate-sulfate in character, but included sodium bicarbonate types.

The effect and timing of industrial waste discharges were noticeable at this station. Analyses of grab samples indicate that the range of chloride concentrations in the flows ordinarily varied from a low of 100 parts per million during low flows to a high of 165 parts per million during high flows.

According to the reclamation criteria these sewage flows were suitable for reclamation, since the weekly average of total dissolved solids was 698 parts per million, chloride averaged 104 parts per million, chloride plus sulfate averaged 270 parts per million, and boron averaged 0.73 parts per million. Several grab samples collected at this sampling station during 1960 indicated no significant change in the mineral quality of the waste water flows in this trunk sewer.

<u>South Whittier Outfall</u>. This outfall serves the City of Whittier and vicinity. The sampling station on this trunk sewer is south of Imperial Highway on Carmenita Road. Flow at this station amounts to about three percent of the total flow discharged to the ocean from the Joint Disposal Plant.

During the week of sampling, the flows at this station varied from a weak to a strong waste water with suspended solids averaging 979 parts per million, and biochemical oxygen demand ranging from 55 to 270 parts per million.

Analyses of daily continuous samples showed that the flows were principally sodium bicarbonate-sulfate in character, but included sodium chloride-bicarbonate, and sodium bicarbonate-chloride types. The predominant mineral constituents in these flows, averaged from the analyses of the daily samples, were sodium chloride-bicarbonate ions.

At this station, also, the effect of industrial waste discharges on the waste water flows appeared. The chloride concentrations ranged as high as 500 parts per million during low flow to as low as 120 parts per million during high flows. This relationship indicated an off-peak industrial waste discharge as compared with the on-peak industrial waste discharge noted in the discussion of Joint Outfall "B".

These waste water flows were suitable to marginal for reclamation according to the reclamation criteria since the weekly average for total dissolved solids was 888 parts per million, chloride averaged 246 parts per million, sulfate plus chloride averaged 333 parts per million, and boron averaged 1.2 parts per million. A limited number of grab samples collected at this sampling station in 1960 indicates that the mineral quality of waste water in this trunk may have degraded and is now marginal according to the reclamation criteria.

Joint Outfall "G". The sampling station on this trunk is west of the intersection of Bort Street and Gale Avenue in the North Long Beach area.

The flow past this station amounted to about 11 percent of the total discharge to the ocean from the districts.

During the week of sampling, the flows at this station varied from a medium to a strong waste water with suspended solids averaging 690 parts per million, and biochemical oxygen demand ranging from 130 to 260 parts per million.

Analyses of daily continuous samples showed that the flows were principally sodium sulfate-bicarbonate and sodium sulfate in character. The predominant mineral constituents in these flows as averaged from the analyses of the daily samples were sodium sulfate-bicarbonate ions.

Analyses of grab samples collected at periods of high and low flows during the week of sampling indicated no regular time of industrial waste discharge.

These waste water flows were marginal for reclamation according to the reclamation criteria since the weekly average values of total dissolved solids were 1,360 parts per million, chlorides 157 parts per million, chloride plus sulfate 613 parts per million and boron 1.8 parts per million.

Joint Outfall "E". The sampling station on this trunk is north of Greenleaf Drive on Alameda Street in the Compton area. The flow passing this station constituted about seven percent of the total discharge to the ocean by the County Sanitation Districts of Los Angeles County.

During the week of sampling, flows at this station varied from a weak to a strong waste water with suspended solids averaging 1,070 parts per million, and biochemical oxygen demand ranging from 65 to 380 parts per million.

Analyses of daily continuous samples indicated that the flows were principally sodium chloride-bicarbonate in character, but included sodium bicarbonate-chloride types. However, an average of the analyses of the daily continuous samples indicated a sodium chloride-bicarbonate type water.

Analyses of grab samples collected during the week of sampling indicated no consistent variation in chloride concentration. This is because of the irregular time and amount of industrial wastes discharged. One grab sample collected during high flows contained 965 ppm chloride. This was 167 percent higher than the next highest chloride concentration, indicating how industrial waste discharges may grossly deteriorate the mineral quality of waste water flows for a short period of time.

The waste water flows as a whole were marginal for reclamation according to the reclamation criteria as the weekly averages of the analyses showed 1,150 parts per million total dissolved solids, 271 parts per million chloride, 468 parts per million chloride plus sulfate, and 1.6 parts per million boron.

County Sanitation Districts of Orange County

During the week from March 20 through March 27, 1955, a detailed sampling program was carried out at the two primary sewage treatment plants of the County Sanitation Districts of Orange County. The locations of these plants are shown on Plate 2. The total flow from these two plants constituted about five percent of the total ocean disposal of waste water from the Los Angeles Metropolitan Area during 1954-55. Complete mineral analyses are presented in Table E-11, Appendix E. A summary of the analyses of daily composite samples is presented in Table 14. Phenol and sanitary analyses are presented in Tables E-12, and E-13, Appendix E.

TABLE 14

SUMMARY OF ANALYSES OF DAILY COMPOSITE SAMPLES FROM THE
COUNTY SANITATION DISTRICTS OF ORANGE COUNTY SEWERAGE SYSTEM

	$EC \times 10^6$ at 25° C	Constituents in parts per million																	Per-cent sodium
		Ca	Mg	Na	K	NH_4	CO_3	HCO_3	SO_4	Cl	NO_3	F	PO_4	B	SiO_2	Total dis-solved solids	Fixed solids	Total hard-ness as $CaCO_3$	
Plant No. 1 Effluent, March 20 through March 26, 1955																			
Minimum	1645	59	17	231	16	33	0	376	264	158	0	-	30	0.50	20	995	908	236	63
Maximum	1880	76	26	248	17	41	0	392	288	209	0	-	38	0.70	25	1074	1010	268	68
Average weighted by flow	1820	66	21	238	17	35	0	385	272	190	0	-	32	0.63	24	1030	959	251	65
Plant No. 2 Effluent, March 21 through March 27, 1955																			
Minimum	5780	92	54	1100	27	26	0	463	240	1600	0	-	10	3.80	30	3400	3247	469	82
Maximum	6850	97	78	1250	32	37	0	503	272	1950	0	-	30	4.18	30	4088	3893	560	83
Average weighted by flow	6228	95	68	1172	30	30	0	476	260	1802	0	-	18	4.04	30	3756	3590	517	82

It has already been pointed out that the large quantities of oil field brines ordinarily discharged to this sewerage system were all diverted to Plant No. 2 during the sampling program. Under this arrangement, only the primarily domestic flows from the Cities of Santa Ana and Costa Mesa were treated at Plant No. 1. The remainder of the flows, including oil field brines, were treated at Plant No. 2. The rate of flow through Plant No. 1 during the week of sampling amounted to about 28 percent of the total discharge by the districts to the ocean during that period.

Plant No. 1. During the week of March 20 through March 26, 1955, analyses of three daily composite samples of the effluent showed a range of 0.06 to 0.08 parts per million phenol. These values exceeded the upper limit of 0.001 parts per million for phenol given in the United States Public Health Service Drinking Water Standards for mineral constituents in water for domestic use. Average concentrations of sulfate for the week exceeded the nonmandatory limit of the drinking water standards by about nine percent, and total dissolved solids exceeded it by three percent. The trace metals, copper, manganese, chromium, iron, lead, zinc and arsenic, and the common constituents magnesium and chlorine all conformed to the drinking water standards.

Monthly averages during the period of July through December 1954 indicated that the effluent from Plant No. 1 contained 103 to 118 parts per million suspended solids, 198 to 251 parts per million biochemical oxygen demand, and 33 to 49 parts per million grease.

During the week of sampling these waste water flows were suitable to marginal for reclamation, with weekly averages of 1,030 parts per million total dissolved solids, 190 parts per million chloride, 462 parts per million chloride plus sulfate, and 0.6 parts per million boron. Plate 19 presents in graphical form the values of selected mineral constituents found in the weekly composite samples, the daily composite samples, and the grab samples with the highest electrical conductance and/or chloride for the day.

It has been mentioned that the quality of water supplied to a sewered area combined with mineral pickup through normal domestic and industrial uses affects the quality of the resultant waste water. A major portion of the Santa Ana-Costa Mesa area is supplied with Colorado River water, which contains more dissolved minerals than the local well water. Colorado River water supplied to the sewered area in March of 1955 contained 81 parts per million chloride, and 660 parts per million total dissolved solids. Analysis of the weekly sample from Plant No. 1 showed 192 parts per million chloride and 1,010 parts per million total dissolved solids. This indicates a mineral pickup of 111 parts per million chloride and 350 parts per million total dissolved solids, both of which were somewhat above the normal range presented in Table 7. There are plans to sewer new industries through Plant No. 2 so it may be possible to prevent further deterioration of the influent to Plant No. 1, but the more drastic segregation of industrial wastes in the Santa Ana-Costa Mesa area that would be necessary to reduce the present mineral pickup may not be feasible.

Plant No. 2. This treatment plant is located near the Pacific Coast Highway and the Santa Ana River. During the week of sampling, about 72 percent of the total flow from the districts was treated at this plant.

Analyses of daily composite samples from the effluent during the week of March 21 through March 27, 1955, indicated that the flows were consistently sodium-chloride in character. The oil field brines diverted to this plant during the sampling program accounted for this.

During the sampling program the effluent was unsuitable for reclamation, and Class 3, injurious to unsatisfactory, for irrigation. The average analyses for the week as computed from the daily composite samples showed 3,756 parts per million total dissolved solids, 1,802 parts per million chloride, 2,062 parts per million chloride plus sulfate, 4.0 parts per million boron, and 82 percent sodium.

Minor Flows

The waste water flows from the City of Seal Beach, United States Naval Ammunition and Net Depot, Los Alamitos Naval Air Station, and Sunset Beach Sanitary District constituted approximately 0.1 percent of the total flow from the Los Angeles Metropolitan Area in 1955.

Because these flows form a very small part of the total waste water flow from the Los Angeles Metropolitan Area, the discussion of the quality of the flows from each of these minor discharge areas is brief. This discussion is based on results of sampling programs undertaken for earlier investigations. It may be noted that all the samples of the minor flows were grab samples except the one for the City of Seal Beach, which is an analysis of a seven-day composite sample. Table E-14, Appendix E, presents complete mineral analyses of samples of the four minor discharges.

City of Seal Beach. Analysis of a seven-day composite sample of waste water flows from the City of Seal Beach indicated a sodium chloride-bicarbonate effluent. This effluent was suitable for reclamation, with 243 parts per million chloride plus sulfate, 0.6 parts per million boron, 180 parts per million chloride, and 691 parts per million total dissolved solids. The discharge was Class 3 for irrigation because of the 76 percent sodium.

Sunset Beach Sanitary District. The waste water flows from this district were affected by salt water infiltration of the sewers, as evidenced by the high concentrations of sodium chloride ions. These flows were therefore unsuitable for reclamation, and injurious to unsatisfactory for irrigation. The flow contained 6,863 parts per million total dissolved solids, 3,420 parts per million chloride, 3,709 parts per million sulfate plus chloride, and 0.8 parts per million boron.

Los Alamitos Naval Air Station. The principal mineral constituents in the waste water flows from Los Alamitos Naval Air Station, judging from one grab sample, were sodium-calcium bicarbonate ions. These flows were suitable for reclamation, and excellent to good for irrigation, with values of 27 parts per million chloride, 68 parts per million chloride plus sulfate, 0.2 part per million boron, 379 parts per million total dissolved solids, and 48 percent sodium.

United States Naval Ammunition and Net Depot. The principal mineral constituent of the waste water flows from the United States Naval Ammunition and Net Depot based on a grab sample was sodium bicarbonate. These sewage flows were suitable for reclamation, with 71 parts per million chloride, 112 parts per million chloride plus sulfate, 0.1 part per million boron, and 539 parts per million total dissolved solids. The discharge was Class 2 for irrigation purposes because of the 74 percent sodium.

Summary of Mineral Quality of Waste Waters

A summary of mineral quality of waste waters at selected sampling stations in the four major sewerage systems in the Los Angeles Metropolitan Area and results of comparison of average analyses with standards for urban and agricultural use is presented in Table 15. The mineral quality of waste waters from the area is depicted graphically on Plate 4.

A summary of analyses for trace constituents in the waste water from each of the sampling and flow measurement stations established is presented in Table 16. Mandatory and recommended drinking water standards established by the United States Public Health Service in 1946 are also presented as a standard of comparison.

Future Mineral Quality of Waste Water

In planning long-term projects for the reclamation of water from wastes, the future mineral quality may well be the most difficult factor to predict. Evaluation of existing quality can serve only as a guide to future quality. Factors which will improve the mineral quality of waste water available for reclamation are: increased use of water for domestic purposes (the per capita consumption of water has been steadily increasing in the past decade with resultant decrease in the mineral pickup); increased utilization of centrally regenerated water softeners in lieu of home regenerated softeners; the segregation of industrial wastes of poor quality and conveyance of such wastes in separate sewers; improvement in quality of water supplied to the sewered areas; and reduced infiltration of poor quality water as a result of better sewer construction.

The use of centrally regenerated water softeners in lieu of home regenerated units will probably increase resulting in improved quality of domestic sewage. The average mineral quality of water supplied to the sewered areas is expected to degrade slightly as the importation of Colorado River water increases; however, the mineral quality will improve markedly with importation of large amounts of water from Northern California.

The agencies responsible for providing the water supply and sewerage facilities in the area could do much to deter further degradation of the mineral quality of waste water by the complete or partial segregation of saline industrial wastes, and the allocation of the better quality waters to areas upstream of potential reclamation plants.

The legal problems associated with maintaining the quality of sewage are complex but are largely within the control of the agency owning and operating a sewerage system. An agency owning and operating a sewerage system has the legal right, within reasonable limits, to establish and enforce discharge requirements, and by so doing can effectively maintain the quality of sewage to be used in a reclamation project. Where sewage is diverted for reclamation under contract, conditions regarding maintenance of quality could be incorporated in the contract.

It is believed that under an adequately planned and operated large-scale reclamation program, the present suitable mineral quality of sewage flows at diversion points proposed in Chapter VI of this report can be maintained and probably improved.

TABLE 15

SUMMARY OF MINERAL QUALITY OF WASTE WATER AT SELECTED SAMPLING STATIONS IN THE LOS ANGELES METROPOLITAN AREA SEWERAGE SYSTEMS

Agency and station	Mineral quality concentrations, in parts per million				Suitability of mineral quality	Conformance to United States Public Health Service Drinking Water Standards limits for mineral concentration		Irrigation classification
	TDS	Cl	$Cl+SO_4$	B		Mandatory	Recommended	
City of Los Angeles								
Valley Settling Basin Effluent	693	109	368	1.10	Suitable	Yes	No	Class 2
Glendale Outfall Sewer at Partridge Avenue	624	103	212	0.96	Suitable	Yes	No	Class 2
Glendale Outfall Sewer at Fourth Street and Mission Road	736	133	249	0.78	Suitable	Yes	No	Class 2
North Outfall Sewer at Manhole No. 1 near Sepulveda Boulevard	775	164	303	1.26	Suitable	Yes	No	Class 2
Central Outfall Sewer north of intersection of Florence and Ash Avenues	790	165	313	1.11	Suitable	Yes	No	Class 2
Venice Pumping Plant Influent	3,500	1,510	1,904	1.23	Unsuitable	No	No	Class 3
Hyperion Sewage Treatment Plant Effluent	900	237	392	0.89	Suitable to marginal	Yes	No	Class 2
Terminal Island Treatment Plant	2,430	1,012	1,231	2.22	Unsuitable	Yes	No	Class 3
County Sanitation Districts of Los Angeles County								
Joint Outfall "B" Loma Avenue and Klingerman Street	698	104	270	0.73	Suitable	Yes	No	Class 2
South Whittier Outfall south of Imperial Highway on Carmenita Road	888	246	333	1.16	Suitable to marginal	Yes	No	Class 2

SUMMARY OF MINERAL QUALITY OF WASTE WATER AT SELECTED SAMPLING STATIONS
IN THE LOS ANGELES METROPOLITAN AREA SEWERAGE SYSTEMS
(continued)

Agency and station	Mineral quality concentrations, in parts per million				Suitability of mineral quality	Conformance to United States Public Health Service Drinking Water Standards limits for mineral concentration		Irrigation classification
	TDS	Cl	$Cl+SO_4$	B		Mandatory	Recommended	
County Sanitation Districts of Los Angeles County (continued)								
Joint Outfall "G" west of intersection of Bort Street and Gale Avenue	1,360	157	613	1.80	Marginal	No	No	Class 2
Joint Outfall "E" north of Greenleaf Drive on Alameda Street	1,150	271	468	1.56	Marginal	Yes	No	Class 2
County Sanitation Districts of Orange County								
Plant No. 1 Effluent	1,030	190	462	0.63	Suitable to marginal	Yes	No	Class 2
Plant No. 2 Effluent	3,756	1,802	2,062	4.04	Unsuitable	Yes	No	Class 3

TABLE 16

COMPARISON OF SELECTED MINERAL CONSTITUENTS OF WASTE WATER AT SAMPLING STATIONS WITH UNITED STATES PUBLIC HEALTH SERVICE DRINKING WATER STANDARDS, 1946

Standard or agency and station	Constituents in parts per million											
	Pb^a	F^b	As^a	Cr^{+6a}	Cu^a	Fe plus Mn^a	Mg^b	Zn^a	Cl^b	$SO_4{}^b$	Phenol	Total solids[b]
United States Public Health Service Drinking Water Standards, 1946[c]												
Mandatory limits	0.1	1.5	0.05	0.05	--	--	--	--	--	--	--	--
Nonmandatory, but recommended	--	--	--	--	3.0	0.3	125	15	250	250	0.001	500[d] 1,000[e]
City of Los Angeles												
Valley Settling Basin:												
Influent	0.0	1.7	0.0	0.02	0.01	0.14	18	0.6	97	81	0.06	666
Effluent	0.0	0.5	0.0	0.01	0.2	0.11	18	0.6	109	259	0.05	693
Glendale Outfall Sewer:												
At Partridge Avenue	0.0	1.1	0.0	0.01	0.03	0.14	21	0.2	103	109	0.04	624
At Fourth Street and Mission Road	0.0	1.1	0.0	0.01	0.02	0.13	21	0.2	133	116	0.05	736
At Eighth Street and Mission Road	0.0	1.0	0.0	0.01	0.03	0.11	20	0.8	130	150	--	735
North Outfall Sewer at Manhole No.1 near Sepulveda Boulevard	0.0	1.2	0.01	0.02	0.05	0.24	21	0.8	164	139	0.06	775
Central Outfall Sewer north of intersection of Florence and Ash Avenues	0.1	1.3	0.0	0.01	0.01	0.34	20	1.0	165	148	0.06	790
Venice Pumping Plant	0.0	1.0	0.0	0.09	0.07	0.25	116	0.7	1,512	392	--	3,495
Hyperion Treatment Plant:												
Influent	0.0	1.1	0.0	0.06	0.01	0.27	24	0.7	247	118	0.05	853
Primary effluent	0.0	1.1	0.0	0.03	0.07	0.13	29	0.8	238	150	--	907
Final effluent	0.0	1.4	0.01	0.03	0.06	0.14	26	0.4	237	155	0.04	900
Terminal Island Treatment Plant	0.0	1.3	0.04	0.01	0.16	0.6	65	0.2	1,012	219	--	2,430

COMPARISON OF SELECTED MINERAL CONSTITUENTS OF WASTE WATER AT SAMPLING STATIONS WITH UNITED STATES PUBLIC HEALTH SERVICE DRINKING WATER STANDARDS, 1946
(continued)

Standard or agency and station	Constituents in parts per million											
	Pb[a]	F[b]	As[a]	Cr^{+6}[a]	Cu[a]	Fe plus Mn[a]	Mg[b]	Zn[a]	Cl[b]	SO_4[b]	Phenol	Total solids[b]
County Sanitation Districts of Los Angeles County												
Joint Outfall "B" at Loma Avenue and Klingerman Street	0.0	0.8	0.0	0.0	0.0	1.1	14	0.05	104	166	0.0[f]	698
South Whittier Outfall south of Imperial Highway on Carmenita Road	0.0	0.6	0.0	0.0	0.0	2.9	17	0.4	246	87	0.0[f]	888
Joint Outfall "G" west of intersection of Bort Street and Gale Avenue	0.0	2.1	0.0	0.0	0.0	0.65	22	0.05	157	456	0.0[f]	1,360
Joint Outfall "E" north of Greenleaf Drive on Alameda Street	0.0	0.9	0.0	0.0	0.0	2.5	24	0.3	271	197	0.63[f]	1,150
County Sanitation Districts of Orange County												
Plant No. 1 effluent	0.0	--	0.0	0.0	0.0	0.0	21	0.0	190	272	0.07[g]	1,030
Plant No. 2 effluent	0.0	--	0.0	0.0	0.0	0.0	68	0.0	1,802	260	0.05[g]	3,756

a. Weekly composite of hourly grab samples, composited by flow.
b. Weekly average weighted by flow of daily composite samples.
c. Daily composite of grab samples by flow.
d. Desirable.
e. Permitted.
f. Average of grab sample analyses.
g. Average of three daily composite samples.

San Gabriel Spreading Grounds

Courtesy of Los Angeles Coun
Flood Control District

"... spreading grounds ... would be available
... for about ten months out of each year."

CHAPTER V. POSSIBLE BENEFICIAL USES OF RECLAIMED WATER

Markets for reclaimed water are prime factors in evaluating the feasibility of reclamation of water from wastes. This chapter discusses the possible beneficial uses of reclaimed water and the quality and quantity of reclaimed water which can be used. Present potential markets for the direct use of reclaimed water include industry, certain types of agriculture, and recreational facilities. Reclaimed water used to recharge ground water aquifers and to repel sea-water intrusion would indirectly serve most beneficial uses.

Some of the present water requirements of possible markets for the direct use of reclaimed water in the Los Angeles Metropolitan Area are presented in Table 17. The water requirements were computed by multiplying the area of the proposed market by the unit water use value for that particular market. The areas of the proposed market were obtained from data collected during the land use surveys conducted by this department in Los Angeles County during 1955 and in Orange County during 1957. The unit water use values were those presented in State Water Resources Board Bulletin No. 2.[14] The probable ultimate requirements presented in Table 17 were derived also from data collected for preparation of State Water Resources Board Bulletin No. 2.

The quantities presented in Table 17 represent the entire estimated requirements for these uses within the Los Angeles Metropolitan Area; therefore, these requirements should be regarded as the maximum probable demand for these uses. The places of use are dispersed throughout the area, and only those places of use which could be economically served from possible reclamation plants should be considered potential markets. Therefore, the actual requirements of these types of use which could be met with reclaimed water will be less than the indicated maximum demand.

TABLE 17

ESTIMATED MEAN SEASONAL WATER REQUIREMENTS
FOR POSSIBLE USES OF RECLAIMED WATER
IN THE LOS ANGELES METROPOLITAN AREA

Possible use	Quantity of reclaimed water required		
	Units	Under present conditions	Under probable ultimate conditions
Industrial and manufacturing	Acre-feet per year	225,000	635,000
	Percent of total water requirement	17.7	23.8
Crops not directly consumed by humans[a]	Acre-feet per year	90,000	37,000
	Percent of total water requirement	7.1	1.4
Parks	Acre-feet per year	58,000[b]	221,000[c]
	Percent of total water requirement	4.6	8.3

a. Pasture, alfalfa, and hay and grain.
b. Miscellaneous - includes parks, cemeteries and golf courses, as well as types of water use such as schools which do not constitute a market for reclaimed water.
c. Parks only.

Industrial Use

Certain industrial uses of water as in high quality paper manufacture and boiler feed make-up require a degree of mineral purity exceeding that specified in the United States Public Health Service Drinking Water Standards. Water suitable for domestic purposes often has to be treated to make it suitable for industrial purposes. It would therefore be wise, before rejecting a possible industrial market on the basis of mineral quality, to compare the mineral quality of the reclaimed water to that of the regularly available supply. Proper treatment may make reclaimed water as suitable for these industrial purposes as presently used water supplies.

Examples of the most likely potential industrial uses are cooling water, wash water, and process water. Industries presently classified as potential users of reclaimed water include oil refineries, metal rolling mills, paper manufacturing plants, aggregate processing plants, steam power plants, chemical plants, and rubber manufacturing plants. Assuming that for aesthetic and public health reasons direct domestic use of reclaimed water is not desirable, it follows that the use of such waters in food processing and related industries would be equally undesirable.

Industrial use of reclaimed water would require a separate distribution system to and within each plant. In general, it appears economically feasible to supply only concentrated groups of industries which would constitute relatively large markets for reclaimed water. In the Los Angeles Metropolitan Area the concentrated industrial regions are centered about Vernon, Torrance, Wilmington, and El Segundo.

It is estimated on the basis of a 1955 land use survey of Los Angeles County that the industrial water requirement in the four areas mentioned is about 164,000 acre-feet per year. Preliminary studies of industrial water use suggest that three-fourths of the industries in these localities could utilize reclaimed water, and that the potential use of reclaimed water within any industry would be about two-thirds of its total water demand. This would mean that under 1955 cultural conditions there is a potential industrial market for reclaimed water approximating 82,000 acre-feet per year in the Los Angeles Metropolitan Area. The requirements by area are estimated at 45,000 acre-feet in Vernon, 20,000 acre-feet in Wilmington, 11,000 acre-feet in Torrance, and 6,000 acre-feet in El Segundo.

The quantity of water required by a specific industrial plant depends on the products manufactured. The cost of the raw materials, the process involved in production, the availability and cost of water, and the effort of management to conserve water, either by re-use within individual plants or by actual reclamation carried on at a central reclamation plant, will determine the quantity of water required at each industrial plant.

The quality requirements for industrial purposes also vary according to the product manufactured. A general breakdown of industrial water quality requirements was presented in Chapter IV to establish criteria for reclamation of water from wastes. The general limits of mineral concentrations, physical characteristics, and bacterial quality for water used in industry are listed in Table 8.

Agricultural Use

The amount of treatment required for protection of health when crops are irrigated with sewage is set forth in Sections 7897 through 7901 of the California Administrative Code, Title 17, Public Health. Effluent from a primary sewage treatment plant that is undisinfected may be used on nursery stock, cotton, and such field crops as hay, grain, rice, alfalfa, sugar beets, fodder corn, cow beets, and fodder carrots, provided that dairy cows are not pastured on the land while it is moist from effluent irrigation and do not have access to ditches carrying sewage or effluent from the sewage treatment plant. This type of effluent cannot be used on any growing vegetables, truck crops, berries, vineyards, or low-growing fruits and orchard crops during season when the fruit may be in contact with the ground. However, these restrictions do not apply to the use of well-oxidized, non-putrescible, and reliably disinfected or filtered effluents which meet certain strict bacteriological standards. These standards correspond approximately to those of the United States Public Health Service Drinking Water Standards.

The present and probable ultimate applied water requirements of crops not used directly by humans and therefore deemed suitable for irrigation with reclaimed water are presented in Table 17. The crops in this category for which data are available are pasture, alfalfa, and hay and grain. Under 1955 cultural conditions, about 70 percent of the agricultural water requirement for crops not used directly for human consumption is for pasture; a good portion of which may be excluded from irrigation with reclaimed water because of the presence of dairy cows. In any case the proportion of the total water requirement represented by this potential market will substantially decrease under conditions of ultimate urbanization of the metropolitan area. Since the restricted agricultural use which survives urbanization must necessarily be widely dispersed, it is probable that a large-scale, separate distribution system to carry reclaimed water for agricultural use would not be economically feasible in the Los Angeles Metropolitan Area.

Use for Recreational Facilities

Irrigation of lawns, flowers, trees, and shrubs in parks and golf courses is a potential use for reclaimed water in the Los Angeles Metropolitan Area. Waste water has been reclaimed at a separate activated sludge treatment plant for use in Golden Gate Park in San Francisco since 1932. Water reclaimed from wastes is currently being used for irrigation of at least seven golf courses in Southern California and a number of similar projects are being planned.

Table 17 shows the present and probable ultimate consumptive water requirement for parks and similar areas. This use constitutes a small part of the total water requirement under present conditions. Under ultimate conditions the water requirement for parks will increase substantially. In general, parks are too small and widely dispersed to be economically served by reclaimed water. Nevertheless, certain conditions might make the use of reclaimed water at recreational facilities economically feasible. This would occur when a large recreational area is close to a reclamation plant, or when a recreational service area is within the same locale as an industrial service area and the two could be integrated. A good example of the first condition is Griffith Park located near the Valley Settling Basin. It is estimated that approximately 3,000 acre-feet annually might be utilized for irrigation in Griffith Park at the present time, and because the park is large, a much greater market is conceivable under ultimate conditions of development. As for the second condition, any large recreational area within the Vernon, Wilmington, Torrance, or El Segundo industrial districts would be a potential market for reclaimed water.

Water used for irrigating recreational facilities would have to satisfy mineral quality standards similar to those for agricultural use.

Ground Water Basin Recharge

Artificial spreading of surface runoff to recharge ground water basins has been practiced for many years in the Los Angeles Metropolitan Area. In spite of this artificial recharge, excessive use of the ground water has caused ground water levels to fall to elevations below sea level resulting in intrusions of sea water along the coastal margins of the metropolitan area. This critical condition might be alleviated if spreading operations could be increased and continued during the dry seasons by using reclaimed water. The most serious manifestations of overdraft are exhibited in the coastal plain area where, in addition to an actual insufficiency of recharge, the confined aquifers underlying a large portion of the coastal plain lack capacity to transmit ground water from recharge areas to areas of extraction at rates necessary to maintain ground water levels above sea level.

The two direct methods of artificially recharging ground water basins are surface spreading and direct injection into ground water aquifers. The advantages of direct injection over surface spreading are reduced land costs, better control of the operation, and the elimination of nuisance. However, economic considerations make the surface spreading method preferable in areas of unconfined ground water. The Montebello Forebay Area is the principal area where recharge of the ground water basins of the Coastal Plain of Los Angeles County can be accomplished by surface spreading. The Los Angeles Forebay Area is essentially covered by streets and buildings and surface spreading for recharge would not be possible without incurring substantial right-of-way costs. In Orange County, surface spreading of local and imported water for ground water recharge is practiced in the Santa Ana Forebay Area. Along the coastal margins of the metropolitan area the ground water aquifers are confined and artificial recharge can only be accomplished by injection. This method is particularly important in the formation of ground water mounds as a barrier to sea-water intrusion. This potential use for reclaimed water is discussed in a later section.

Although it would appear that the spreading of sewage for recharge of ground water basins would be the best method of effecting beneficial use of reclaimed water, there are several factors to be considered in evaluating the practicability of such a program. Among these factors are the possibility of polluting the receiving ground water, availability of land areas for spreading grounds, recharging capacities of the spreading grounds, availability of underground storage capacity for the regulation and distribution of reclaimed water, and maintenance of a favorable salt balance in the ground water basin.

Possible Pollution of Receiving Ground Water

There have been many investigations to determine the rate of travel of pollution through soils. The downward movement of bacteria with percolating water has been shown to be very limited and of little importance by experiments under field and pilot plant conditions.[1] [10] It must, however, be presumed as a safety factor that under certain conditions some organisms will reach the ground water. For this reason, the proximity of downstream wells should be considered when determining the suitability of spreading grounds for spreading water reclaimed from wastes.

Since water recharged into the ground water basins will eventually be used for all major beneficial uses, the mineral quality of such water should not greatly exceed the United States Public Health Service Drinking Water Standards.

Views of the California State Department of Public Health on the use of reclaimed water for ground water recharge have been expressed in a letter by the Director of Public Health. The letter was published as an appendix to, "A Report Upon the Potential Reclamation of Sewage Now Wasting to the Ocean in Los Angeles County".(23) The following quotations have been abstracted from the cited report:

> "As applied to reuse of any waste waters, our conclusions are that they should be well oxidized and disinfected, and in addition, a long time factor should be provided by artificial storage or by flow through underground formations before mingling with usable ground waters.
>
> "Direct discharge of sewage effluents to recharge wells reaching ground waters would undoubtedly be protested by water users, and we think it should not be considered. If such effluents are at all times oxidized, and further purified by sand filtration, adequate disinfection and chemical oxidation to meet the bacterial standard of Section 7900, Title 17, Public Health, California Administrative Code, the resulting reclaimed water might be acceptable for recharge if the injection wells were separated from water supply wells by a distance sufficient to allow both time and dilution with natural waters in the ground water basin. We believe these are minimum requirements necessary for public health safety to obtain public acceptance of such proposals. We also believe that each case should be reviewed and monitored regularly to make certain that unusual soluble materials such as excessive chemical constituents, which may pass through the treatment processes, are not allowed to reach the ground water basin."

Research by the University of California conducted at its Engineering Field Station in Richmond(12) dealt with rate of travel of bacteria with moving ground water. Waste water containing coliform concentrations as great as 4.7×10^6 organisms per 100 milliliters were injected at various rates. In no case did these high concentrations travel farther than 100 feet in the direction of ground water flow, or 63 feet in other directions. Concentrations of organisms at these distances were 23 or less per 100 milliliters. The removal of bacteria by an aquifer was shown to be a function of distance and filtering characteristics of the aquifer rather than of rate of recharge. The conclusion was reached by the University investigators that the reclamation of waste water by direct recharge into sand aquifers is not limited by public health concern over bacterial contamination. It was recommended, however, that provision for monitoring the ground water bacterially and chemically be a part of any practical recharge project.

Another public health consideration in the use of reclaimed water for ground water recharge is the viability and underground travel of pathogenic viruses. There are a number of virus diseases of human beings which are recognized as possibly being carried by water.[4] [31] Among these diseases are inclusion conjunctivitis, hepatitis, and poliomyelitis. Hepatitis is the only one of these for which water is known to be the major vehicle of transmission. Inclusion conjunctivitis has on rare occasions been contracted in swimming pools, although the disease is normally of genital origin. Poliomyelitis virus has been isolated from sewage; but Maxcy[28] considers transmission of poliomyelitis by water very unlikely.

The effect of chlorination on the virulence of both hepatitis and poliomyelitis viruses has been studied.[27] [31] Hepatitis viruses have survived as long as 40 minutes in water with chlorine residuals of one part per million measured after 30 minutes. Poliomyelitis viruses are inactivated by 0.05 part per million free chlorine measured after 10 minutes contact over the normal pH range of waters. The virus is inactivated under any circumstances after 10 minutes contact in 0.2 part per million free chlorine measured after 10 minutes. Water treatment plus chlorination does reduce the concentration of viruses or their virulence or both.

There is, at present, no information available on the underground travel of viruses. The existing methods for determining the presence of viruses in water are so laborious and uncertain that field investigation is impracticable. However, when techniques for the isolation and identification of viruses improve, consideration should be given to the initiation of such a field investigation.

At Chanute, Kansas, during a period of direct re-use of reclaimed water, tests for viruses were made on raw sewage, treated sewage, raw water, and tap water. Only two of the 40 samples tested yielded positive results for pathogenic viruses. These two positive samples were collected from the sewage treatment plant effluent.[30]

Availability of Spreading Grounds

To be successful, spreading grounds used for artificial recharge of ground water should be located in areas of high infiltration capacity, where large underground storage capacity exists, and where recharge is needed. In the Los Angeles Metropolitan Area these locations are generally near the foothills while the amount of waste water is a maximum near the coast. The potential spreading areas are being reduced as urbanization continues. Fortunately, however, there are 36 spreading grounds in this area and in 1959 they had a net wetted area of about

1,976 acres. Of these spreading grounds 4 with a net wetted area of 583 acres were located at a point where the waste water volume was enough to make reclamation and recharge of the ground water with the effluent reasonable.

Any spreading ground in the metropolitan area would be near urban development and therefore tne nuisance factors must be carefully considered. If an effluent from a secondary type of treatment plant is utilized, there will be very little odor or nuisance problem. However, mosquitos and other insects breeding in spreading basins can create a nuisance and health hazard unless control measures are adopted. If algae odors are pronounced, the control of algae will also be necessary.

Spreading grounds now utilized for percolation of flood waters can be made available for the spreading of reclaimed water provided that such use does not interfere with the primary purpose. Obviously flood control spreading grounds would not be available for the spreading of reclaimed water when occupied by storm runoff waters. The Los Angeles County Flood Control District estimated that its spreading grounds along the Rio Hondo in the coastal plain of Los Angeles County would be available for spreading other than storm runoff for about ten months out of each year.

Recharging Capacities of Spreading Grounds

The estimated recharging capacities of flood control spreading grounds in the metropolitan area are presented in Table 18. The recharging capacities are based on the long-time infiltration rates found to prevail for storm water runoff. The estimates of recharge capacities assume low ground water levels, and ground water levels near the ground surface would reduce these recharge capacities.

TABLE 18

ESTIMATED INFILTRATION CAPACITY OF SPREADING GROUNDS AND USABLE STORAGE CAPACITY OF GROUND WATER BASINS IN THE LOS ANGELES METROPOLITAN AREA

Location	Net wetted area, in acres	Spreading ground infiltration capacity, in acre-feet per day	Estimated usable storage capacity, in acre-feet*
San Gabriel Valley	597	1,490	1,500,000
Coastal Plain			
Los Angeles County	583	1,190	1,580,000
Orange County	453	992	460,000
San Fernando Valley	343	1,070	900,000
TOTALS	1,976	4,742	4,340,000

*Estimated usable storage capacity - The ground water storage capacity of the alluvial fill between the historic high ground water level and some lower ground water level defined in each basin by some critical condition.

On the basis of experiments conducted at the Lodi Sewage Treatment Plant(10), it is believed that the infiltration rate of reclaimed water will be similar to that for fresh water. Secondary treatment, or equivalent, of waste water to be used for spreading is required in order to obtain high rates of infiltration.

Storage Capacities of Ground Water Basins

The adequacy of each ground water basin for underground storage and distribution of reclaimed water depends not only upon its recharging and usable storage capacity but also transmissibility, pumping pattern, head differential, and the distance from the area of recharge to the area of use. Although the San Gabriel and San Fernando Valleys have considerable recharging and storage capacity, as noted in Table 18, it may not be practicable to recharge these basins with reclaimed water because they are located at higher elevations than most of the potential reclamation plant sites, and because of the possibility that an unfavorable salt balance may develop.

Salt Balance

When the amount of salt added to a ground water basin by water entering the basin exceeds the quantity of salts removed from the ground water basin by water leaving the basin over a prolonged period of time, the salt content may increase to a point which would render the water in the underground reservoir unusable. Waste water discharges in outfall sewers are the principal outflow from many of the ground water basins in the metropolitan area, and therefore, a prime means of removing salts from the basin. Continued gross recirculation of waste water outflow back into a ground water basin could result in a serious water quality problem.

In this report careful consideration has been given to the problem of salt balance in ground water basins when estimating the quantities of waste water reclaimable for recharging ground water basins particularly those of the inland areas. Generally, only the coastal portion of the metropolitan area has been considered suitable for possible recharge, since reclaimed water spread in these areas would for the most part be used only once before disposal to the ocean. The potential market areas selected for industrial use of reclaimed water minimize cyclic re-use of the water and attendant mineral pickup. Most of the Vernon, Torrance, and Wilmington industrial areas are served by the sewerage system of the County Sanitation Districts of Los Angeles County. Since these areas are below any of the potential reclamation plant sites on this system, the reclaimed water would be discharged to the ocean after only one use. The El Segundo industrial area, served by the Hyperion Treatment Plant of the City of Los Angeles, would have to discharge its wastes directly to the ocean or another sewerage system to prevent recycling water reclaimed from the Hyperion Plant.

Repulsion of Sea-Water Intrusion

The Los Angeles County Flood Control District operates a series of injection wells in the West Coast Basin to maintain a fresh water barrier against sea-water intrusion along one and one-half miles of the 11 miles of Santa Monica Bay coast line open to sea-water intrusion (see Plate 21). Direct injection is employed in this project because the principal ground water aquifers of the West Coast Basin are overlain by thick layers of silt and clay of low permeability. At the present time, treated and softened Colorado River water supplied through facilities of The Metropolitan Water District of Southern California is being injected at the rate of about five cubic feet per second. Future plans of the Los Angeles County Flood Control District call for an extension of the line of injection wells along the Santa Monica Bay and San Pedro Bay coast lines, a total distance of about 16 miles. This extension of the barrier along Santa Monica Bay alone will require an increase of the injection rate to about 75 cubic feet per second or 54,000 acre-feet per year (1959 estimates).

Together with the recharging operations, experiments were conducted by the Los Angeles County Flood Control District to determine the minimum chlorine dosage required to maintain maximum well acceptance rates. It was concluded that a chlorination rate of more than 5 parts per million and less than 10 parts per million was required at the test site to control the growth of slime-forming bacteria which tended to clog the well. "Shock" treatment of 20 parts per million or more of chlorine was recommended at intervals.

The Los Angeles County Flood Control District conducted experiments utilizing the effluent from the Hyperion Sewage Treatment Plant in order to determine an economical and acceptable method of providing a polishing treatment for sewage treatment plant effluent so that it could be utilized for injection.[26] A conclusion reached from the experiment was that intermittent spreading in small basins one to four times daily, allowing time for soil re-aeration between spreading cycles, was a highly effective supplemental treatment. By this treatment the biochemical oxygen demand and the suspended solids content of the activated sludge treatment effluent were reduced 90 to 95 percent. This method was not found to be practical in the West Coast Basin because of lack of sufficient areas of suitable land for construction of the required number of basins; however, it is believed that it may be possible to use rapid sand filters for this purpose.

The experiments of the Los Angeles County Flood Control District demonstrated that adequately treated sewage plant effluent could be successfully injected into a recharge well for extended periods of time. Direct injection of effluent from the experimental, standard rate, activated sludge process could not be accomplished, demonstrating that treatment in addition to this type of secondary treatment is required before effluent can be injected in recharge wells.

In addition to these experiments, the State Water Pollution Control Board sponsored a 44-month field study of direct recharge into underground formations. The work was performed from May 1951 to December 1954 by the University of California at its Engineering Field Station in Richmond. In the course of this study[12] fresh water was recharged into a pressure aquifer having a permeability of about 1,900 gallons per square foot per day at a rate of 8.4 gallons per minute per foot width of aquifer for long periods without difficulty. The addition of sewage plant effluents at the same rate, however, caused clogging of the well at a rate proportional to the amount of solids injected. Most of the work was done with 20 percent primary settled sewage and 80 percent fresh water. This combination was used to simulate, in terms of suspended solids and biochemical oxygen demand content, the final effluent from a secondary treatment plant. It was recognized, of course, that the solids in primary sewage are biochemically less stable than the solids in a final effluent. This instability could result in a clogging potential greater than that of the final effluent, hence experimental conditions were probably more rigorous than those to be expected in a full-scale operation.

Under permissible well head pressure build-up, an equivalent to the final effluent from secondary sewage treatment was injected for about eight or nine days. At that time redevelopment was necessary. Chlorine injection followed by a half-day of contact and three or four hours of pumping at a rate equal to twice the injection rate completely re-established the ability of the aquifer to receive injected water. Experience with recharge well operation demonstrated a need to gravel pack the recharge well. One of the conclusions of the pollution control board report was that the problems of recharge well operation were the critical factors in the use of water reclaimed from wastes for direct recharge rather than the danger of pollution travel.

Legal Considerations

Reclamation of water from sewage in the Los Angeles Metropolitan Area does not present serious legal problems, although consideration must at all times be given to regulations which are imposed on such activity by local ordinances, the California Board of Public Health and by the State and Regional Water Pollution Control Boards. In addition, due care would be required in the operation of a project, the location of any spreading grounds, and the maintenance of water quality to avoid litigation based on theories of negligence or nuisance.

Health and Safety Code Sections 5410 to 5413 prohibit discharges of sewage effluent in any manner which will result in contamination, pollution, or a nuisance, and give the California Department of Public Health power to abate contamination. Power to issue regulations concerning pollution and nuisance resulting from discharges of sewage effluent or reclaimed water is vested in the regional water pollution control boards by Water Code Section 13053. Use of reclaimed water through injection into an aquifer is permitted by Section 4458 of the Health and Safety Code, upon a finding by the regional water pollution control board that "water quality considerations do not preclude" injection operations, and under the supervision of the State Board of Public Health.

With the above qualifications, all of the relationships necessary to utilize reclaimed water fall into established contractual and water rights patterns. The user of reclaimable water would want to assure himself of rights to a firm enough supply to warrant investment in treatment facilities. Probably users and effluent producers would want to execute agreements concerning quality of the water and liability for failures in the systems.

Public bodies should be certain that they have power to enter into the necessary agreements to utilize reclaimable water. Power to sell or dispose of effluent for reclamation is expressly granted by Health and Safety Code Section 5008 to cities, counties, corporations, and districts operating sewage systems. Many districts, including districts formed under the County Water District Act and the Water Replenishment District Act have express powers to use sewage effluent as a supply source. The Metropolitan Water District of Southern California and Los Angeles County Flood Control District are considered to have the power to make use of satisfactory sewage effluent on the same basis as any other water supply.

Use of effluent for ground water recharge operations would be subject to the many uncertainties which presently attach to control and storage of water in underground basins. The existence of an appropriate water replenishment or other district, preferably with power to levy a pumping tax, is highly desirable for such activities.

Construction of a Trickling Filter and Cnlorination Facilities at the County Sanitation Districts of Orange County Plant No. 2

Courtesy of
Western City Magazine

"Water reclaimed from waste waters requires secondary treatment for utilization by most available markets."

CHAPTER VI. PLANS FOR RECLAMATION OF WATER

After the location, quantity, and quality of waste water supplies in the Los Angeles Metropolitan Area were delineated and potential markets for reclaimed water identified, it was possible to formulate plans for reclamation projects which would make reclaimed water available for beneficial use. This chapter presents the concepts and assumptions used in formulating reclamation proposals and several possible metropolitan area water reclamation developments. Brief descriptions of these proposals are presented herein; the detailed cost estimates are contained in Appendix D. However, the estimated unit costs for reclaimed water at the proposed points of use are presented in this chapter. Also included for comparative purposes are the unit costs of water from other sources.

Basic Concepts and Assumptions

Essential to the formulation of plans for proposed reclamation plants is the development of basic concepts and general assumptions to guide these plans. Within these basic concepts is the human element, which requires serious consideration of the aesthetic conditions, as well as the physical limitations, which require investigation of the reclamation process, extent of treatment required for the proposed use, costs of plants, changes in mineral quality and characteristics, and special design considerations. The aesthetic requirement limits the type of use made of reclaimed water, while the physical considerations place limits on the amount available for use. In the following paragraphs these criteria and assumptions are discussed as they apply to the reclamation developments proposed herein.

Aesthetic Considerations

Most people have an almost instinctive revulsion against anything connected with sewage. This attitude is attributed to four factors. First, people generally tend to dissociate themselves from waste materials of any type. Second, the subject of human fecal material provokes acute feelings of embarrassment and unpleasantness making objective consideration difficult. Third, septic sewage has an obnoxious odor. Fourth, inadequate treatment and disposal of domestic sewage can spread disease. For all these reasons, waters carrying domestic wastes are generally disposed of as inconspicuously as possible.

However, water has been unconsciously re-used for a long time. Probably the most obvious example is the situation where communities have been established along a major stream. An upstream city withdraws water, uses it, and discharges its waste back into the stream. Subsequently, a downstream city withdraws water, including a portion of the waste from the upstream city for its water supply. Although the natural purification ability of a stream affords some protection to public health, the magnitude of this almost direct re-use of water has necessitated installation of plants for water purification and waste treatment.

A less obvious re-use of water is by replenishment of ground water supplies. The connection between sewage discharged to a septic tank and the crystal clear water withdrawn from a downstream well is seldom considered. In the area of investigation, before completion of the present sewerage systems, domestic wastes discharged to the ground contributed substantially to the water supply of downstream areas.

Although such re-use of water is commonplace, there is still considerable reluctance about the planned use of reclaimed water.

Generally there must be some special incentive, either a definite economic advantage or the unavailability of other supplies, before a planned program for the use of water reclaimed from wastes is inaugurated. Prejudice against sewage would be a drawback to any large-scale reclamation program, but this should not preclude its success.

The successful inauguration of any large-scale reclamation program would require a considerable amount of education. Careful selection of terms would be helpful. The use of the terms "waste water" instead of "sewage"; "reclaimed water", "spent water", or "used water" instead of "sewage water"; "water reclamation plant" instead of "sewage treatment plant"; and similar phraseology would materially alleviate mental blocks to the reclamation of water from sewage.

Reclamation Process

Water reclamation should be an independent operation separated from waste water disposal. This would permit the reclamation plant to by-pass undesirable flows and to shut down in an emergency. The quantity of water diverted to the reclamation plant should be regulated to reduce fluctuations in flow. Because of the strong tendency for waste waters to become septic, it is believed that regulation by storage reservoirs prior to treatment would not be feasible. As total flow in the sewer increases during the life of the project, the minimum flow will approach the design capacity of the reclamation plant and result in essentially uniform flow through the plant.

If a reclamation plant is located upstream from a sewage disposal plant, sludge disposal facilities may be omitted. The sludge resulting from the reclamation process may be returned to the sanitary sewer for disposal at the downstream sewage treatment plant as usual. With the help of a small storage reservoir, this discharge of sludge into the sewer could be accomplished at times of peak flow. This would make sludge digestion and drying facilities unnecessary except where there was more than one reclamation plant on a given outfall sewer, or where the reclamation plant was combined with a sewage treatment plant.

Treatment Necessary for Water Reclamation

Water reclaimed from waste waters requires secondary treatment for utilization by most available markets. The two major competitive types of secondary treatment processes are trickling filter and activated sludge. The standard rate activated sludge process was chosen for cost estimating purposes. By using this method, 95 percent of biochemical oxygen demand and suspended solids can be removed. It is also a flexible process which can be adjusted to the strength of the waste water and degree of removal desired. As an example, some basic operating data of the three major activated sludge plants of the Sanitary District of Chicago, Illinois, are presented in Table 19.

Cost of Water Reclamation Plants

Since there are very few planned reclamation projects, estimates of the cost of water reclamation plants must be based on the cost of sewage treatment plants. Estimated construction and operating costs of sewage treatment plants for various capacities are presented in a "Report on the Collection, Treatment and Disposal of the Sewage of San Diego County, California".[5] These costs are typical for treatment facilities constructed in California, and assume a normal variation in flow.

The cost of waste water treatment by the activated sludge process varies with the capacity of the plant. The greater the capacity, the lower the annual cost per unit quantity of water treated. The capacity of sewage treatment plants is based on average daily flows. Because of the more uniform flow expected through a reclamation plant, a higher degree of biochemical oxygen demand and suspended solids removal would be possible than in a sewage treatment plant.

TABLE 19

AVERAGE OPERATING DATA OF MAJOR ACTIVATED SLUDGE PLANTS OF THE SANITARY DISTRICTS OF CHICAGO, ILLINOIS*

Description	North side plant	Calumet plant	West southwest plant
Number of years (inclusive) represented	1946 to 1950	1946 to 1950	1951 to 1952
Sewage treated, in millions of gallons per day	213	77	794
Raw sewage, in parts per million			
Suspended solids	135	146	185
Five-day biochemical oxygen demand	102	109	143
Final effluent, in parts per million			
Suspended solids	9	14	15
Five-day biochemical oxygen demand	6	11	7
Removal from raw sewage, in percent			
Suspended solids	93.5	91.8	92.0
Five-day biochemical oxygen demand	94.0	90.0	94.7

* Abstract of table taken from transactions of the American Society of Civil Engineers, Vol. 120, 1955; Paper No. 2743, page 356. "Sewage Aeration Practice in Chicago" by Norval E. Anderson.

As previously stated, the proportion of the cost of treatment allocated to reclamation should be limited to that over and above charges necessary for proper sanitary disposal. Thus, for purposes of this report, the cost of reclamation at existing treatment plants was assumed equal to that required to provide additional treatment of the effluent, if any, and to make it available for use. When the proposed reclamation plants were located on trunk sewers upstream from sanitary disposal plants, the cost of sludge disposal was omitted. Based on calculations presented in the "Report on the Collection, Treatment and Disposal of the Sewage of San Diego County, California"[5], it was assumed for this case that the capital and operating costs of a reclamation plant would be 75 percent of those of a complete activated sludge sewage treatment plant.

The construction and operating costs of water reclamation plants of various capacities are shown on Plate 20. They were adjusted to prices prevailing in September 1960, by means of the Engineering News-Record Construction Cost Index. Costs of administration, engineering, contingencies, and land acquisition are not included on this plate.

Demineralization

As mentioned previously, sanitary treatment has no significant effect on the dissolved mineral constituents of the influent water. Waste water containing excessive concentrations of dissolved mineral constituents would require extensive and costly treatment to produce a reclaimed water of suitable quality for most uses. The only economical methods which can presently be employed to decrease mineral concentrations are dilution with water of better quality, elimination of the pollution at its source, or bypassing the highly mineralized flows.

Although methods to reduce the dissolved salt content are known, such as distillation plants employing multiple-effect evaporators or vapor compression-distillation apparatus, their present high cost has prevented the construction of extensive saline water reclamation projects. Other methods such as ion-exchange, solar evaporation, crystallization, chemical precipitation, and freezing are also too expensive for practical consideration on a large scale. However, increased development work within the past few years has resulted in considerable reduction of the cost for many of these processes and some may become economically feasible in the future. For brackish waters the process of electrodialysis has been brought near the threshold of economic feasibility. This process utilizes the semi-permeable properties of certain types of membranes which permit only the passage of cations in parallel with other types of membranes which will only pass anions. By using electrical forces to pull cations and anions through these ion-selective membranes, partially demineralized water is left behind.

The greatest potential use of the membrane type of electrodialysis is for demineralization of brackish waters (waters containing less than 10,000 parts per million, total dissolved solids). Construction, replacement, and power costs are a function of the amount of dissolved salt that is removed. Therefore, reclamation costs are lowest for brackish waters. This process thus shows promise in the field of demineralization of waters of marginal mineral quality. The cost will also vary with plant capacity and the cost of electrical power.

It has been estimated that the cost of demineralizing water from a total dissolved solids concentration of 1,600 parts per million to 500 parts per million at a rate of two million gallons per day would be $0.42 per thousand gallons or about $130 per acre-foot.[25] The most probable source of brackish water of any large magnitude in the Los Angeles Metropolitan Area is waste water, and if this source were used the costs of demineralization would be in addition to the costs of reclamation treatment considered herein.

Design Considerations

Independent upstream reclamation plants have an optimum capacity at which the unit cost of treatment is the most economical. This optimum capacity is influenced by conveyance costs both to and from the reclamation plant. Except where noted, the capacity of the reclamation plants proposed herein was assumed to be 80 percent of the average daily flow in the tributary sewer during the week of sampling. This reduction in capacity would provide a more nearly uniform flow to the plant and allow for the flushing of sludge for disposal elsewhere. Although estimates of staged construction were not made for purposes of this report, additions could be made to a reclamation plant when warranted by increased flow in the sewer.

Separation of conduits conveying reclaimed water from those used for domestic water supply is essential for public health and aesthetic reasons. When determining the economic feasibility of waste water reclamation, it is necessary to include the cost of a separate distribution system from the plant to the potential area of use.

In the specific proposals for reclamation projects that follow, estimates of the cost of conveying water from the reclamation plant to the center of potential market areas are included. It is believed that such conduits would be operated on a continuous flow basis, since the demand for water by industry or for ground water recharge is fairly uniform. Any peaking capacity required by industry could be provided by pumping from the local ground water supply. However, small storage reservoirs with capacity sufficient for approximately one day's flow were included in the estimates of cost to provide regulation of minor variations in flow from the reclamation plant and to meet small variations in industrial demand. The conduit routes would generally follow streets, and the cost of resurfacing the streets is included in the estimates.

Because of the unavailability of good-sized and suitable areas of undeveloped land for additional spreading grounds, it was assumed that existing spreading grounds would be recharged with reclaimed water whenever possible. Although there should be no charge for capital recovery of the cost of the grounds, an extra cost of one to two dollars per acre-foot for operation and maintenance is chargeable to reclamation. Since a similar cost would be chargeable to any other source of imported water utilized for ground water replenishment, this spreading cost was not included in the following economic analyses.

Detailed Reclamation Proposals

In developing plans for reclaiming water from wastes, consideration was given to the location of potential diversion points and possible markets, as well as to the quantity and quality of waste water supply available. Reconnaissance estimates were made to determine the feasibility of conveying reclaimed water to potential markets. These estimates indicated that conveyance of reclaimed water to markets outside the Los Angeles Metropolitan Area was not feasible because of excessive cost. The detailed reclamation proposals that follow include conveyance to the more feasible market areas within the metropolitan area. The location of potential water reclamation plants, conveyance systems, and service areas are shown on Plate 21.

Design features of plans presented herein are necessarily tentative and primarily for cost estimating purposes. The more detailed investigation required in order to prepare construction plans and specifications might result in designs differing in detail from those presented in this report. It is believed that such changes would not result in significant modifications in estimated costs. Estimates of capital costs include costs of construction and rights of way, plus thirty percent of the construction and rights of way cost for administration, engineering and contingencies, and interest during one-half of the estimated construction period at four percent per annum. Estimates of annual costs include interest on the capital investment at four percent, amortization over a forty-year period on a four percent sinking fund basis, replacement, operation and maintenance costs. These estimates of cost of treatment and conveyance for the various proposals are presented in Appendix D.

Hyperion Reclamation Plant

The conversion of the Hyperion Treatment Plant from a secondary to primary type facility, described in the following chapter, has been completed. The secondary treatment facilities have been retained and are available for reclamation purposes. During the fall of 1960 the plant was operating at an average rate of about 260 million gallons per day. Of this amount about 160 million gallons per day received only primary treatment and about 100 million gallons per day received both primary and secondary treatment.

The effluent from the secondary treatment process during the fall of 1960 averaged about 850 parts per million total dissolved solids, 10 parts per million suspended solids, and 8 parts per million biochemical oxygen demand. This effluent contains some of the highly mineralized flow from the Venice trunk sewer. The mineral quality of the plant effluent could be significantly improved by operating the plant so as to keep this flow out of the secondary treatment facilities.

It has been estimated that the cost of operation and maintenance of the secondary treatment at the Hyperion Treatment Plant chargeable against reclaimed water at the plant is about five dollars per acre-foot of water. In addition to this operating cost, a charge should be added to return the capital cost of the secondary treatment works even though the plant already exists. An estimate of this amount is made in Table D-1, Appendix D, based on the estimated cost of secondary treatment facilities. From Table D-1, the annual cost of the Hyperion Reclamation Plant would be $1,230,000. For an annual yield of 116,000 acre-feet, this amounts to $10.60 per acre-foot, including the $5.00 per acre-foot operating cost.

The flow at the Hyperion Treatment Plant during 1959-60, less the potential upstream diversions of 49,000 acre-feet per year described later in this chapter and less the estimated 17,000 acre-feet per year flow in the Venice trunk sewer was about 225,000 acre-feet per year. The proposed 116,000 acre-foot per year yield from the plant would be about 50 percent of the annual flow through the plant. The minimum flow through the plant during the sampling program was about 48 percent of the daily average flow, therefore, it appears that flow through the reclamation plant would be fairly uniform.

Conveyance of this reclaimed water to three major service areas was considered. One conduit would serve the heavy industries in Vernon and vicinity with approximately 45,000 acre-feet of reclaimed water per year. Another conduit would supply about 17,000 acre-feet per year of reclaimed water to industries near El Segundo and Torrance. The proposed recharge of the West Coast Basin by injection wells would utilize about 54,000 acre-feet of reclaimed water per year.

Vernon. The first section of the conduit to the Vernon service area, with a capacity of 75 cubic feet per second and a diameter of 54 inches, would extend due east from Hyperion. A pumping plant with capacity of 75 cubic feet per second would be located at Hyperion and another of similar capacity would be required approximately 36,000 feet further east. From the second pumping plant the conduit would extend northerly from Lynwood to Huntington Park, serving industries in the vicinity of South Gate. In Huntington Park, it would divide into two sections. One section would serve Vernon and its environs and the other the East Los Angeles industrial area. The two similar conduits would consist of reinforced-concrete pipe 33 and 36 inches in diameter and have capacities of 25 cubic feet per second each. A terminal reservoir with a storage capacity of approximately 65 acre-feet would be provided at the end of each of these sections. The capital cost of the whole conveyance system is estimated to be about $10,000,000. Corresponding annual costs would be $810,000 or approximately $18.00 per acre-foot of water served. If the unit cost of reclaimed water at Hyperion is $10.60 per acre-foot, the total unit costs of water to the Vernon service area would be about $28.60 per acre-foot.

Torrance and El Segundo. The conduit to the Torrance service area would also serve oil refineries and similar industries in El Segundo. The first section would consist of a reinforced-concrete pipe 42 inches in diameter with a capacity of 29 cubic feet per second commencing at a pumping plant of the same capacity at Hyperion. This 7,000 foot section would follow streets to a point on El Segundo Boulevard where an outlet for industries in the El Segundo area would be located. From that point, a 30-inch diameter pipeline with a capacity of 17 cubic feet per second would continue along El Segundo Boulevard to the Southern California Edison Company power line right of way, thence southeasterly along that right of way and the Atchison, Topeka, and Santa Fe railroad right of way to Del Amo Boulevard; thence easterly to a point about 1,500 feet east of Western Avenue, a distance of about 11.5 miles from the Hyperion Reclamation Plant.

The capital cost of the conveyance system to the Torrance area is estimated at $1,820,000. The annual cost is $156,000 or approximately $9.20 per acre-foot of water delivered. If the unit cost of water reclaimed at Hyperion is $10.60 per acre-foot, the total unit cost of reclaimed water to the El Segundo and Torrance service area would be $19.80 per acre-foot.

Recharge of West Coast Basin. Proposals to protect the ground waters of the West Coast Basin from sea-water intrusion by creating a fresh water mound along the coast were discussed in the preceding chapter. It is believed that water reclaimed from Hyperion Treatment Plant would require a polishing treatment before direct injection into the ground water aquifer in order to reduce the problems of injection well operation.

Studies by the Los Angeles County Flood Control District indicate that a satisfactory treatment would be rapid sand filtration followed by chlorination. The unit cost of such treatment would depend upon the degree of clarification and disinfection, and the capacity of the plant. It is estimated that the unit cost of "upgrading" the quality of the reclaimed water for use in injection wells would be on the order of $5 per acre-foot.

Such a water treatment plant could be located immediately east of the Hyperion Sewage Treatment Plant on unoccupied land within the city limits of El Segundo. Preliminary estimates indicate that the vacant space is adequate for a plant of about 75 cubic feet per second capacity. Although the cost of right of way should not be excessive, some site preparation such as leveling would be required. It is believed that operation of the plant would not be objectionable to residents in the immediate vicinity.

The water would have to be pumped from Hyperion Treatment Plant to the polishing treatment plant and from there into the conduit serving the injection wells. Preliminary estimates indicate that the unit cost of pumping to an elevation of about 150 feet would be about $3 per acre-foot. This would provide the same amount of pressure to supply the reclaimed water to the series of injection wells as water delivered from an alternative source. The costs of the injection wells and connecting conduit are not included in this discussion because they would be necessary regardless of the source of the water. The unit cost of supplying reclaimed water to such a recharge project would be the sum of the unit costs of reclamation, polishing treatment, and pumping or about $18.60 per acre-foot.

Whittier Narrows Reclamation Plant

The Rio Hondo Spreading Grounds have been considered as a potential recharge area for reclaimed water.(1) These are the largest spreading grounds in the Coastal Plain of Los Angeles County and they are favorably located in the Montebello Forebay subarea of this important ground water basin. There is a satisfactory site for a reclamation plant in this area immediately downstream of the Whittier Narrows Dam.

Although there are trunk sewers passing through Whittier Narrows, their flows are of unsuitable mineral quality. The nearest diversion point having a flow of suitable mineral quality is located on Joint Outfall "B" of the County Sanitation Districts of Los Angeles County at Loma Avenue and Klingerman Street in the City of El Monte. The nearest diversion point of any consequence in the sewerage system of the City of Los Angeles is located on the Glendale Outfall Sewer at Eighth Street and Mission Road. Consideration was given to diversion and conveyance of waste waters from both of these stations to the Whittier Narrows Reclamation Plant. Although the unit cost of conveyance from the Glendale Outfall Sewer would be considerably greater than that from Joint Outfall "B", the unit cost of treatment would be less utilizing sewage from both sewers than if the reclamation plant were operated on the flow from only one of these sewers.

Conveyance from Joint Outfall "B" would be by gravity flow in a reinforced-concrete pipe 48 inches in diameter which would be placed along a route approximately parallel to the outfall sewer. This conveyance pipeline would be about 2.8 miles in length, and have a capacity of 60 cubic feet per second. The proposed diversion site is located upstream of the maximum pool area of the Whittier Narrows Flood Control Basin, but the conduit would pass through the reservoir and dam. With appropriate construction precautions, such a conduit would serve satisfactorily. It would divert approximately 80 percent of the average annual flow in the sewer.

Conveyance from the Glendale Outfall Sewer would also be by gravity flow in a conduit about 8.9 miles in length with a capacity of 100 cubic feet per second. The first 0.7 mile of conduit would be a tunnel to avoid construction difficulties in the congested area of eastern Los Angeles. The remaining 8.2 miles of conduit would consist of 66 and 72-inch diameter pipe and would follow a route along Olympic Boulevard and the west bank of the Rio Hondo. Studies indicate that it would be most economical to divert approximately 77 percent of the average annual flow in the sewer.

The capacity of the reclamation plant would be 120 cubic feet per second. This is less than the capacity of the Rio Hondo spreading grounds. Releases from the reclamation plant could be conveyed by means of the concrete-lined Rio Hondo Channel and diversion works to the spreading grounds. Additional spreading capacity is available if needed in the San Gabriel Coastal spreading grounds, but some arrangement for conveyance to these grounds would have to be provided. Diurnal variations in flow from the reclamation plant could be regulated by the storage available in the ponds created by the spreading grounds.

The Los Angeles County Flood Control District indicates that the spreading grounds would be available on the average of ten months per year for spreading other than local storm water. The proposed plant would reclaim about 26,000 acre-feet of water per year from Joint Outfall "B" and 46,000 acre-feet of water per year from Glendale Outfall Sewer, for a total of about 72,000 acre-feet of water per year. A summary of the costs of conveyance and treatment associated with the Whittier Narrows Reclamation Plant is presented in Table 20.

TABLE 20

SUMMARY OF ESTIMATED COSTS AND YIELDS OF
RECLAMATION AT WHITTIER NARROWS

	Capacity, in: acre-feet per year	Capital costs	Annual Costs: Total	Annual Costs: Per acre-foot of capacity
Whittier Narrows Reclamation Plant	72,000	$15,000,000	$1,350,000	
Conduit from Joint Outfall "B"	26,000	740,000	41,000	
Conduit from Glendale Outfall Sewer	46,000	5,070,000	271,000	
TOTALS	72,000*	$20,810,000	$1,662,000	$23.10

* Total capacity

South Whittier Outfall

As indicated in Chapter IV, there is probably an off-peak industrial waste discharge into the South Whittier Outfall. Elimination of this highly mineralized flow could change the reclamation classification of the flow from marginal to suitable. If this waste were bypassed, probably about 70 percent of the flow could be reclaimed. This would amount to about 4,400 acre-feet per year.

A reclamation plant constructed near the intersection of Imperial Highway and Carmenita Road would have a capacity of about seven cubic feet per second and cost about $1,550,000. The estimated annual cost would be about $162,000 or about $37.00 per acre-foot of yield. Because of the high unit cost of treatment, the costs of conveyance to possible places of use were not estimated.

An alternative possibility would be to convey the waste water to Whittier Narrows and use the treated water for recharge in that vicinity. This would involve pumping the waste water and conveying it about 8.9 miles to the Whittier Narrows Reclamation Plant for treatment at the latter location. The estimated capital cost of the conveyance system would be about $1,330,000 and the annual cost about $99,000. The unit cost of conveyance was estimated to be about $22.50 per acre-foot. Since the unit cost of treatment at the Whittier Narrows Reclamation Plant would not be appreciably changed by this small increase in flow, it is assumed to be the same as previously estimated or $18.80 per acre-foot. The total unit cost of reclamation if this development were considered alone would then be about $41.30 per acre-foot. However, when considered as part of the overall project, the Whittier Narrows Reclamation Plant and the three conduits conveying sewage to it, the unit cost of reclamation would be about $23.10 per acre-foot.

Valley Reclamation Plant

The Valley Settling Basin in Griffith Park could form the nucleus for a reclamation plant providing irrigation water to the park. If the plant capacity were five cubic feet per second, it would yield about 3,000 acre-feet of reclaimed water per year. The capital cost of such a plant would be about $1,120,000. The unit cost of treatment would be about $41.00 per acre-foot of yield.

The water would be conveyed by two conduits, one of which would connect with the irrigation distribution facilities of the park, and the other would serve the cemetery to the northwest of the park. The pipes would be 15 and 9 inches in diameter respectively and have capacities of four and one cubic feet per second respectively. A new pumping plant of five cubic feet per second capacity was included in the estimate of cost, but the cost of new domestic facilities was not estimated. The cost of electrical energy for pumping reclaimed water for irrigation purposes was not included because it would be required for any source of water. The capital cost of the conveyance system is estimated to be $173,000. The annual cost would be about $15,000 or $5.00 per acre-foot of yield. Thus, the total unit cost of reclamation would be about $46.00 per acre-foot.

Talbert Water District

Trustees of the Talbert Water District have entered into an agreement with the County Sanitation Districts of Orange County to purchase a portion of the effluent from sewage treatment Plant No. 1. Under this 20-year agreement the cost of the effluent would be $0.50 per acre-foot for the first 10 years; at the end of this time, the cost would be adjusted to an amount not exceeding $1.00 per acre-foot.

The Talbert Water District is utilizing the effluent from the primary treatment plant principally for the preirrigation of beans. It was originally proposed to utilize 2,800 acre-feet of reclaimed water per year. Based on this volume, the cost of distribution was estimated by the consulting engineer for the district at $5.35 per acre-foot. The distribution system is shown on Plate 21. The Talbert Water District began using reclaimed water in November 1956; 2,240, 1,720, and 2,300 acre-feet of reclaimed water were used during the calendar years 1957, 1958, and 1959, respectively. The total unit cost of reclaimed water for this project is $5.85 until 1966 and $6.35 thereafter.

Comparative Costs of Supplemental Water

For comparative purposes, Table 21 recapitulates the yields of water that would be developed by the several reclamation proposals and the capital, annual, and unit costs of this water. The unit costs and yields of the projects are depicted graphically on Plate 22 where the various projects are arranged in order of increasing cost.

The Colorado River Aqueduct and the California Aqueduct (part of the Feather River and Delta Diversion Projects) constitute the only sources of water available to the Los Angeles Metropolitan Area not now fully utilized and therefore are the only valid basis of cost comparison with other supplies. The average cost of unsoftened Colorado River water is presently estimated by the Metropolitan Water District of Southern California to be about $35 per acre-foot delivered within the area when all capital and operating costs, including the distribution systems, are considered. The estimated average cost of water from the California Aqueduct presented in the California Department of Water Resources Bulletin No. 78 "Investigation of Alternative Aqueduct Systems to Serve Southern California", dated December 1959, is $58 per acre-foot in the Southern California Coastal Plain. The cost of distribution within the metropolitan area is estimated to be about $10 per acre-foot.

TABLE 21

ECONOMIC COMPARISON OF POTENTIAL WATER RECLAMATION PROJECTS
IN THE LOS ANGELES METROPOLITAN AREA

Sewerage system and project	Annual plant yield, in acre-feet	Capital costs: Treatment	Capital costs: Conveyance	Capital costs: Total	Average annual costs: Treatment	Average annual costs: Conveyance	Average annual costs: Total	Unit costs, in dollars per acre-foot: Treatment	Unit costs: Conveyance	Unit costs: Total
Los Angeles City										
Hyperion-Vernon	45,000	$ —	$10,000,000	$ —	$ —	$810,000	$ —	$10.60	$18.00	$28.60
Hyperion-Torrance	17,000	—	1,820,000	—	—	156,000	—	10.60	9.20	19.80
Recharge of West Coast Basin	54,000	—		—	—		—	15.60	3.00	18.60[a]
Griffith Park	3,000	1,120,000	170,000	1,290,000	123,000	15,000	138,000	41.00	5.00	46.00
Los Angeles County										
Whittier Narrows	72,000	15,000,000	5,810,000[b]	20,810,000	1,350,000	312,000[b]	1,662,000	18.80	4.30[b]	23.10
South Whittier	4,400	—	1,330,000	—	—	99,000	—	18.80[c]	22.50	41.30[d]
Orange County										
Talbert Water District	2,800	—	—	—	—	—	—	0.50[e]	5.35	5.85
	2,800	—	—	—	—	—	—	1.00[f]	5.35	6.35

a. Does not include cost of distribution or injection.
b. Cost of conveyance of waste water to Whittier Narrows Reclamation Plant. Does not include cost of spreading.
c. Unit cost of treatment assumed the same as at Whittier Narrows Reclamation Plant.
d. If this project is combined with the Whittier Narrows Reclamation Plant, the total unit cost would remain at $23.10 for the expanded project.
e. Initial unit cost of effluent delivered by County Sanitation Districts of Orange County.
f. Maximum unit cost of effluent delivered by County Sanitation Districts of Orange County.

Laying a Pipeline for a Growing Community

Courtesy of County Sanitation Districts of Orange County

"Several changes in the major sewerage systems ... have occurred ..."

CHAPTER VII. CHANGES IN SEWERAGE SYSTEMS AND RELATED DEVELOPMENTS SINCE 1955

Several changes in the major sewerage systems within the Los Angeles Metropolitan Area have occurred since 1955, particularly in the City of Los Angeles Hyperion system. Most of these changes either enhance or have little effect on the feasibility of the plans discussed in the preceding chapter. The more significant of these changes and their relationship to the proposed plans are discussed hereinafter.

City of Los Angeles

The City of Los Angeles has essentially completed a major construction program which included construction of the San Fernando-La Cienega Relief and North Central Outfall Sewers and conversion of the Hyperion Treatment Plant from a secondary to a primary type facility.

San Fernando-La Cienega Relief Sewer, Valley Settling Basin, and Glendale Outfall Sewer

The overloaded condition of the Glendale Outfall Sewer, which necessitated construction of the Valley Settling Basin and its temporary operation as a treatment plant in 1955 as previously described, was alleviated by completion of the San Fernando-La Cienega Relief Sewer. The major portion of this sewer, which extends from North Hollywood to Culver City and includes a 17,000 foot tunnel through the Santa Monica Mountains, was completed in 1956. Plate 2 shows this sewer to be under construction. A major portion of the waste water originating in the San Fernando Valley during 1960, and discharged to the City of Los Angeles sewerage system upstream of the tunnel intake, flowed through the relief sewer. The relief sewer also receives flow from the Beverly Hills and

Hollywood areas prior to discharging into the North Outfall Sewer near Culver City.

The average rate of flow through the Glendale Outfall Sewer in 1960 was consequently appreciably less than during the sampling and flow measurement program in 1955. No recent measurements of this flow were readily obtainable. The Valley Settling Basin remained on standby operation for use in event of extremely heavy flows resulting from storm conditions, or during periods in which the La Cienega Tunnel or accompanying trunk sewer is taken out of service for maintenance or repairs.

Although flow in the Glendale Outfall Sewer may be insufficient at the present time to provide the amounts of sewage proposed for diversion at both the Valley Settling Basin and the Eighth and Mission Street station, there is no apparent reason why flow in required amounts could not be diverted to this sewer from the intake of the La Cienega Tunnel. Facilities at that intake permit diversion of flow either to the La Cienega Tunnel or to the Glendale Outfall Sewer in any proportions desired. Flow in the Glendale Outfall Sewer at Eighth and Mission Street, therefore, could be maintained at a fairly constant rate by appropriate regulation of the flow through the La Cienega Tunnel.

North Central Outfall Sewer

The North Central Outfall Sewer, which extends from a point near the intersection of La Cienega Boulevard and Rodeo Road to the Hyperion Treatment Plant, is about eight miles long and was completed during 1958. This outfall sewer receives flow from the Glendale Outfall Sewer and the Central Los Angeles area. The North Outfall Sewer, which received flow from the Glendale Outfall Sewer during 1955, now receives flow from the

San Fernando-La Cienega Relief Sewer, in addition to the flow from the Santa Monica, Venice, and Culver City area.

Hyperion Treatment Plant

Conversion of the Hyperion Treatment Plant from a secondary to a primary treatment plant is virtually complete. Operation of the plant during the fall of 1960 is described in the following paragraphs. Waste water entered the plant at an average rate of about 260 million gallons per day from three outfall sewers; the North Outfall Sewer, the North Central Outfall Sewer, and the Central Outfall Sewer with approximate average flows of 115, 140, and 5 million gallons per day, respectively. Approximately three-fourths of the 115 million gallons per day flow from the North Outfall Sewer was discharged to the West Primary settling tanks which were completed in 1958. The remaining one-fourth of the flow from the North Outfall Sewer and the total flows from the North Central and Central Outfall Sewers were discharged to the Central and East Primary settling tanks. This division of flow provided approximately equal flows to each of the three batteries of primary tanks.

Approximately 100 million gallons per day of waste water from the Central and East Primary settling tanks received secondary treatment and was subsequently discharged to the ocean through the one-mile marine outfall. The remaining flow from the Central and East Primaries and the flow from the West Primary was discharged to the ocean through the recently completed 5-mile, 12-foot diameter marine outfall without receiving secondary treatment.

Following completion of facilities now under construction all effluent from the plant will be discharged to the ocean through the five-mile marine outfall except for small flows discharged through the one-mile marine outfall to keep it in operative condition and suitable for emergency use.

As previously discussed, all waste water flows in the sewerage system discharging to the Hyperion Treatment Plant are suitable according to the reclamation criteria, except for flow from the Venice Trunk Sewer. This sewer discharges to the North Outfall Sewer at a point about two miles upstream from the Hyperion Treatment Plant. Representatives of the City of Los Angeles estimate that by 1962 flow in the three outfall sewers will adjust so that flow in the North Outfall Sewer will not exceed one-third of the total flow through Hyperion Treatment Plant. When this condition is reached all waste water from the North Outfall Sewer will flow to the West Primary settling tank. At that time all flow from the Venice Trunk Sewer will be excluded from the secondary facilities resulting in a definite improvement in the mineral quality of effluent from the secondary facilities.

County Sanitation Districts of Los Angeles County

Total flow through the sewerage system of the County Sanitation Districts of Los Angeles County increased more than 45 percent in the five-year period since the flow measurement and sampling program in 1955. Construction of additional sewerage facilities has proceeded throughout the districts, and the number of connected services has increased significantly. This construction has not changed the possibility of reclamation of sewage from Joint Outfall "B" or the South Whittier Outfall.

Sewerage Facilities

Major sewerage facilities constructed during the five-year period include an additional ocean outfall and major portions of a line from the

Joint Disposal Plant to Whites Point, Joint Outfall "D", and Joint Outfall "H".

A 2-mile, 90-inch diameter outfall was constructed near Whites Point, in addition to the two outfalls shown on Plate 2. The new outfall is located a short distance west of the two older and smaller outfalls. A 12-foot diameter line extending from the Joint Disposal Plant to Whites Point and approximately paralleling the older 8-foot diameter line was also completed. Most of this line is a horseshoe-shaped tunnel through the Palos Verdes Hills.

Joint Outfall "D" was extended about three miles from the Joint Disposal Plant toward the intersection of Normandie Avenue and Carson Street. Joint Outfall "H" and various branch lines of this outfall were constructed between the Long Beach Boulevard crossing over the Los Angeles River in North Long Beach and Baldwin Park 30 miles away.

Whittier Narrows Reclamation Plant

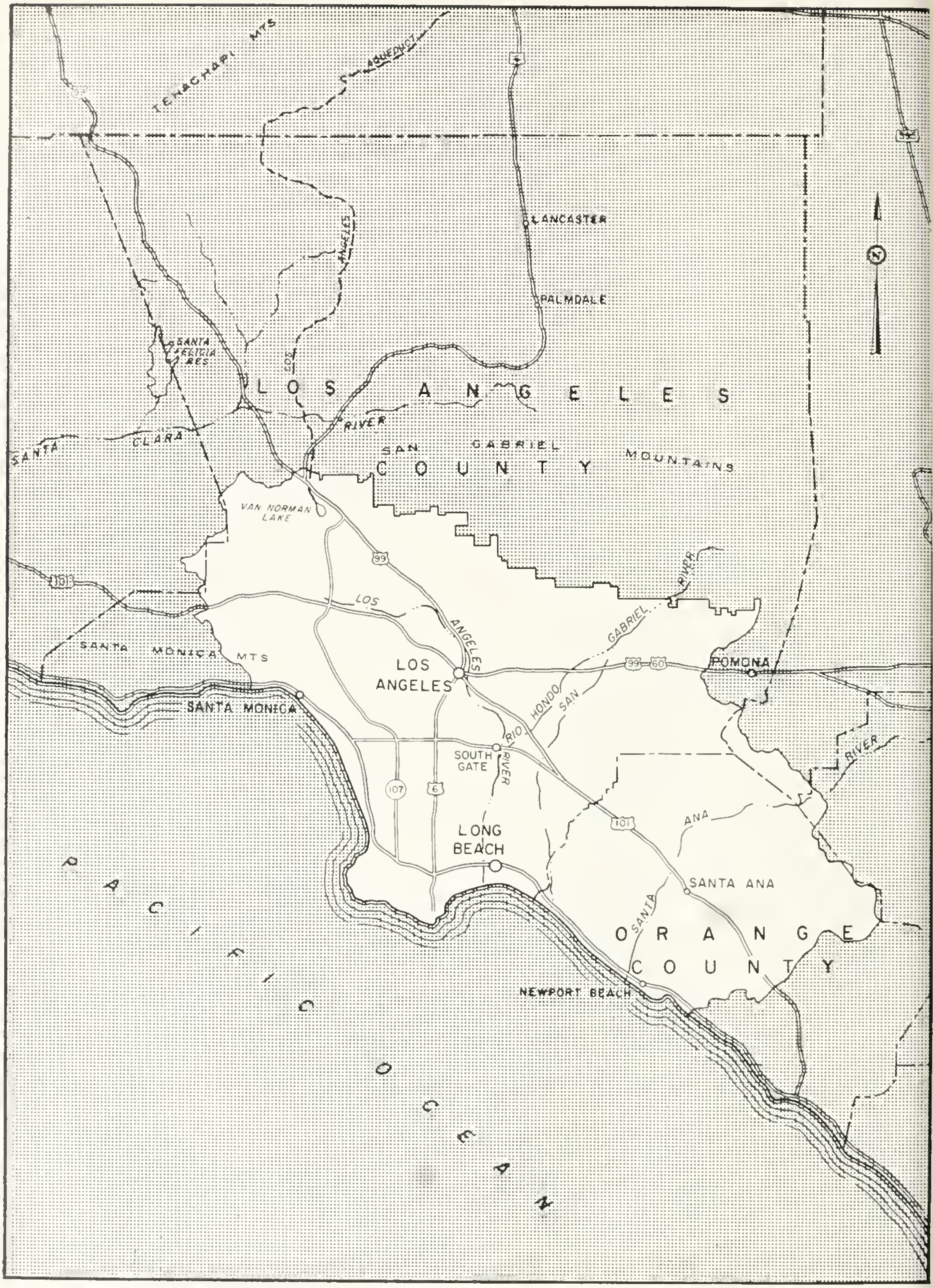
The County Sanitation Districts of Los Angeles County have awarded a contract for construction of a demonstration water reclamation plant to be located within the Whittier Narrows Flood Control Basin Reservoir area. The plant is scheduled for completion in the spring of 1962 and will have a capacity of 10 million gallons per day.

Waste water from Joint Outfall "B" will be diverted at a point about one-fourth mile upstream from the San Gabriel Boulevard crossing over the sewer, and the reclamation plant will be located adjacent to this diversion point. The outfall in this vicinity presently receives flow from the highly mineralized discharge of the F. E. Weymouth Softening and Filtration Plant of The Metropolitan Water District of Southern California located near La Verne. Sanitation district representatives report that the construction required to assure that none of this mineralized flow will enter Joint Outfall "B" upstream from Whittier Narrows Dam will be completed during 1961. Sludge and other waste materials from the plant will be discharged to Joint Outall."B" below the plant. The treated effluent from the plant will be purchased by the Central and West Basin Water Replenishment District and be spread by the Los Angeles County Flood Control District in the Montebello Forebay area to recharge the ground water basins of the coastal plain of Los Angeles County. According to estimates by the Sanitation Districts the purchase price of the water will return the capital investment in the reclamation plant as well as the operation and maintenance charges.

The construction and operation of this plant is considered very significant because this will be the first plant of any appreciable capacity constructed in the Los Angeles Metropolitan Area for the express purpose of planned reclamation of water from wastes. Data collected from construction and operation of this plant will be extremely valuable in evaluation of other possible reclamation projects.

County Sanitation Districts of Orange County

During the period from 1955 to 1960, the quantity of waste water discharged to the ocean from the sewerage system of the County Sanitation Districts of Orange County increased about 158 percent to 60,300 acre-feet. Oil field brines and other highly mineralized flows which were temporarily diverted from Plant No. 1 to Plant No. 2 during the sampling program will be permanently diverted to Plant No. 2 in 1962. The districts plan to construct secondary treatment facilities at Plant No. 1 to improve the quality of the plant effluent. These changes will result in waste water more suitable for reclamation.



"Reclamation of water from wastes now discharged to the ocean is a possible source of additional water supply to the Los Angeles Metropolitan Area".

CHAPTER VIII. SUMMARY OF FINDINGS AND CONCLUSIONS

The detailed description of the methods and procedures followed in the investigation and of the studies of waste water reclamation plans for the Los Angeles Metropolitan Area have been presented in the preceding seven chapters. The principal results of this investigation are summarized in the following findings and conclusions.

Summary of Findings

1. The expanding urban and suburban growth within the Los Angeles Metropolitan Area has created a large demand for water which is supplied to a large extent from the ground water basins of the area and by water imported from great distances. Because it has been more economical to utilize the local ground water, these limited supplies are generally overdrawn. This overdraft has resulted in sea-water intrusion in the coastal ground water basins. Predictions of future growth demonstrate that additional water supplies will be required to provide for the water demand.

2. Discharge to the ocean is the most economical means of disposing of the large quantities of waste water developed in the metropolitan area, and all major agencies charged with the responsibility of waste water disposal have selected this means. More than 99 percent of the waste water discharge to the ocean is conveyed through four sewerage systems owned and operated by three agencies. These are the Hyperion and Terminal Island systems of the City of Los Angeles and the joint outfall systems of the County Sanitation Districts of Los Angeles County and the County Sanitation Districts of Orange County. Approximately 90 percent

of the discharge from the metropolitan area occurs from the City of Los Angeles Hyperion system and the County Sanitation Districts of Los Angeles County joint outfall system.

3. Waste water discharged to the ocean was about 505,000 acre-feet in fiscal year 1954-55 and 648,000 acre-feet in 1959-60. It is estimated that ultimately about 1,636,000 acre-feet of water per year will be discharged through sewerage systems of the area.

4. Reclamation of water from wastes now discharged to the ocean is a possible source of additional water supply to the Los Angeles Metropolitan Area.

5. The sanitary, and to a large extent, bacteriological quality of waste water can be upgraded to meet the basic requirements of many beneficial uses by known and proved methods of primary and secondary sanitary treatment. The type and degree of treatment is a matter of cost. Improvement of mineral quality of waste water is not considered practical at this time because the costs of such treatment would be more than double the cost of primary and secondary treatment alone.

6. Previous investigators have concluded that the reclamation of waste water by direct recharge into sand aquifers is not limited by public health concern over bacterial contamination. However, there is, at present, no information on the underground travel of viruses since the existing methods for determining the presence of viruses in water are so laborious and uncertain that field investigation is impracticable.

7. The factors affecting quality of waste water are the quality of water supplied to the area, the mineral pickup resulting from domestic and industrial use, and the quality and quantity of water

infiltrating into the sewerage system. These factors vary considerably throughout the area and, therefore, the quality of the waste water also varies.

8. Since the cost of upgrading the mineral quality of water is excessive, the mineral quality problem was solved by locating points within the sewerage systems where flows of sufficient quantity and suitable mineral quality for reclamation were available. These points were located by evaluation of information obtained at 19 sampling and flow measurement stations established at selected points throughout the four major sewerage systems.

9. Criteria developed to judge the suitability of mineral quality of waste water for reclamation and used to evaluate and compare data obtained from the sampling program are based on four factors:

Constituent	Limiting values, in parts per million		
	Suitable	Marginal	Unsuitable
Chlorides	Less than 200	200 to 350	More than 350
Chlorides plus sulfates	Less than 500	500 to 1,000	More than 1,000
Boron	Less than 2	2 to 3	More than 3
Total dissolved solids	Less than 1,000	1,000 to 2,000	More than 2,000

10. The flows at eleven of the twelve sampling and flow measurement stations within the Hyperion system were suitable or marginal according to the reclamation criteria; the only station in that system where flow was unsuitable was on the Venice Trunk Sewer. Discharges to the ocean from the other three major sewerage systems were unsuitable for reclamation; however, the flows at four stations on trunk sewers of the County Sanitation Districts of Los Angeles County and at Plant No. 1 of the County Sanitation Districts of Orange County were suitable or marginal.

11. The mineral quality of flows which were suitable or marginal according to the reclamation criteria could be improved by eliminating

certain highly mineralized contributions or bypassing the more highly mineralized flows.

12. Present potential markets for the direct use of reclaimed water include industry, certain types of agriculture, and areas of recreation (irrigation of parks, golf courses, etc.). Reclaimed water used to recharge ground water basins and repel sea-water intrusion into the coastal ground water basins would indirectly serve most beneficial uses. The most promising market for reclaimed water is recharging ground water basins by spreading or injection.

13. Local public agencies within the area have the legal right to construct and operate waste water reclamation projects. The waste water collecting agencies apparently have a legal right to contract with certain other agencies for disposal of waste water. All beneficial uses proposed herein, including injection of reclaimed water into ground water aquifers through wells, are legally permitted providing certain requirements are complied with.

14. In any planned water reclamation project both the water reclamation plant and final waste disposal facilities should be capable of independent operation, but so designed and interconnected that the entire flow of waste water can be processed through the disposal facilities, should it become necessary to bypass or shut down reclamation operations.

15. Conduits conveying reclaimed water must be separate from those used for domestic water supply since public health requirements presently prohibit the direct commingling of drinking water and used water.

16. It would be possible to reclaim at least 116,000 acre-feet of water per year at the Hyperion Treatment Plant and, based on studies conducted in 1956, 45,000 acre-feet of reclaimed water per year could be used by industries in Vernon and East Los Angeles, and 17,000 acre-feet of reclaimed water per year could be used in the Torrance and El Segundo industrial areas. Costs of treatment and delivery of water to the Vernon and East Los Angeles area and to the Torrance and El Segundo areas were computed at $28.60 and $19.80 per acre-foot, respectively, based on price levels of September 1960. The remaining 54,000 acre-feet of water per year possible of reclamation at the Hyperion Treatment Plant could be used for recharging aquifers in the West Coast Basin at an estimated cost of $18.60 for treatment and pumping. The cost of distribution of this latter reclaimed water was considered to be chargeable to the control of sea-water intrusion rather than to reclamation.

17. It would be possible to reclaim 72,000 acre-feet of water per year at a reclamation plant constructed in the Whittier Narrows area at an estimated cost of $23.10 per acre-foot. The waste water for the plant could be obtained from Joint Outfall "B" on the County Sanitation Districts of Los Angeles County joint outfall system and the Glendale Outfall Sewer of the City of Los Angeles Hyperion system. The reclaimed water could be spread at the Rio Hondo spreading grounds of the Los Angeles County Flood Control District to recharge the ground water basins of the coastal plain of Los Angeles County.

18. Approximately 4,400 acre-feet of water per year could be diverted from the South Whittier Outfall at the intersection of Imperial Highway and Carmenita Road to the Whittier Narrows Reclamation Plant and

treated at an estimated cost of $41.30 per acre-foot. Integration of this diversion with the larger reclamation project would reduce the over-all cost to $23.10 per acre-foot for the total yield of 76,400 acre-feet per year.

19. A reclamation plant could be constructed adjacent to the Valley Settling Basin to reclaim about 3,000 acre-feet of water per year for irrigation of a portion of Griffith Park and an adjoining cemetery. The cost of treatment and delivery are estimated at $46.00 per acre-foot.

20. The Talbert Water District has constructed a distribution system designed to utilize up to 2,800 acre-feet of reclaimed water per year for irrigation use at an estimated cost of $5.35 per acre-foot. The reclaimed water utilized is effluent from the primary treatment Plant No. 1 of the County Sanitation Districts of Orange County that presently is sold to the Talbert Water District for 50 cents per acre-foot.

21. Computations presented in this report of amounts of water which could be reclaimed are based on data collected in 1955 and 1956. Providing suitable markets for use of reclaimed water are available, the amount of waste water suitable for reclamation should increase proportionally to the increase in total waste water flow.

22. It is believed that, under a well-planned large scale reclamation program, the mineral quality of selected waste water flows could at least be maintained and probably improved.

Conclusions

As a result of this investigation and considering economic, public health, aesthetic, and other pertinent factors, it is concluded that:

1. Reclamation of water from wastes is feasible in the Los Angeles Metropolitan Area.

2. Of the waste water discharged to the ocean from the Los Angeles Metropolitan Area in 1954-55, about 40 percent or 195,000 acre-feet of water per year can be economically reclaimed.

3. The amount of water available for re-use in the future should increase proportionately with the increase in waste water flows.

4. While reclamation of water from wastes will not provide a complete solution to the water shortages in the Los Angeles Metropolitan Area, it could provide limited amounts of water at prices competitive with imported supplies.

5. Water reclamation plants should be designed as facilities separate from sewage treatment plants. This would insure adequate treatment of waste water in the event reclamation operations were curtailed.

6. Demineralization of sanitary wastes for reclamation purposes is not feasible at this time.

7. Additional studies in the field of water-borne viruses should be encouraged, particularly those oriented toward determination of survival and transmission in underground waters.

8. Reclamation of water from wastes is a part of the California Water Plan and should be actively planned for and developed where economically feasible by the local water distributing agencies.

9. All interested agencies and individuals who recognize the importance of reclaiming water from wastes should take every opportunity to educate the public toward acceptance of reclaimed water. Careful selection of descriptive terms would help overcome the aesthetic objections to use of adequately treated waste water.

APPENDIX A

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APPENDIX A

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APPENDIX B

EXAMPLES OF WASTE WATER RECLAMATION PROJECTS

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EXAMPLES OF WASTE WATER RECLAMATION PROJECTS

Involuntary reclamation of water from sewage is inherent in the disposal of wastes from the earlier and simpler types of water flush sewerage systems. Sewage discharged to a stream, lake, or other surface water body intermixes with, and becomes part of, that water body. In valley fill areas, a portion of the sewage discharged to cesspools and septic tanks percolates to ground water, where, though diluted, it is subject to re-use. The portion of the sewage that does not percolate to ground water is consumptively used.

With increased urbanization, extensive collection systems for sewage disposal have been installed to avoid public health and nuisance problems. In the inland areas these systems, like the simpler variety, discharge to natural watercourses or to percolation grounds. The water so disposed of is involuntarily reclaimed and eventually becomes an integral part of the water supply of downstream areas. In the coastal areas, however, the trend is toward ocean disposal of treated sewage. Many municipalities in the Los Angeles Metropolitan Area, which formerly had sewage treatment plants with inland disposal areas, have abandoned their treatment plants to join one of the four major collection systems which have ocean outfalls, thus reducing the amount of water involuntarily reclaimed.

In addition to the involuntary reclamation of waste water noted above, many planned reclamation projects have been constructed throughout the United States. A few of these projects which exemplify some of the direct uses of reclaimed water are discussed in the following pages.

These descriptions also illustrate the evolution of some of the basic concepts involved in the reclamation of water from sewage.

In Southern California effluent from three planned reclamation projects is utilized for irrigation and ground water recharge and from 14 other projects effluent is used directly for irrigation. In addition, 6 projects now in the planning stage will incorporate water reclamation as an integral part of waste water disposal.

City of Los Angeles, Department of Water and Power

One of the earliest investigations of planned reclamation of water from sewage in the Los Angeles Metropolitan Area was undertaken by the City of Los Angeles, Department of Water and Power, about 1930. It included a detailed survey of the location of existing trunk sewers, the quantity and quality of sewage flow, type and possible locations of reclamation plants, possible uses of reclaimed sewage, and comprehensive cost studies. The results of this investigation were never published.

The most interesting phase of the Department of Water and Power investigation, the construction and operation of a pilot reclamation plant, has been reported in journals. The pilot plant, located in Griffith Park, was a 200,000 gallon per day capacity activated sludge sewage treatment plant designed for reclamation of water, not disposal of sewage.

One-third of the influent to the plant was processed through a complete sewage treatment which included coagulation, superchlorination, sedimentation, sand filtration, and dechlorination with activated carbon. It is reported that Mr. R. F. Goudey, Sanitary Engineer for the Department of Water and Power, would drink the effluent from this complete treatment, much to the amazement of visitors. Analyses of the effluent indicated that Mr. Goudey was drinking a water which compared favorably to an acceptable domestic supply. Table B-1 gives average results of several hundred analyses of this final effluent.

TABLE B-1

AVERAGE ANALYSES OF FLOW IN
WATER RECLAMATION PLANT COMPARED TO
LOS ANGELES CITY SUPPLY*

Item analyzed	Raw sewage	Treated sewage: Settled	Treated sewage: Stabilized	Treated sewage: Fully treated	Los Angeles water, untreated: Aqueduct	Los Angeles water, untreated: Gallery
B. Coli	100,000	50,000	1	0.00	0.05	0.00
Suspended solids	418	77	3.2	0.00	6.0	0.0
Turbidity	440	--	8.3	0.2	25	0
Oxygen demand	515	222	9.1	0.99	1.25	1.0
Oxygen consumed	180	46	8.3	4.1	3.5	1.2
Organic nitrogen	48.1	37.3	5.08	2.25	1.3	0.5
Free ammonia	50	20	1.0	0.65	0.25	0.20
pH	6.8	6.6	7.0	7.1	7.3	7.2

* Table from reprint of "Western City", December 1930 issue.

Azusa Sewage Treatment Plant

The operation of this plant is an example of reclamation of water from sewage for recharge of a ground water reservoir. This trickling filter type plant was constructed in 1940 to treat the sewage from the City of Azusa. The design capacity of the plant was 450,000 gallons per day and the plant effluent was discharged to ponds where it percolated to the ground water.

As the City of Azusa developed, its sewage flow exceeded the capacity of the treatment plant causing the city to join the County Sanitation Districts of Los Angeles County in 1953. A trunk sewer was constructed to carry excess sewage flows to the districts' outfall sewer for final disposal to the ocean.

The sewage treatment plant now operates as a reclamation plant, and during fiscal year 1959-60, an average of about 664,000 gallons of sewage per day was treated and spread in the percolation ponds. Sludge disposal facilities at the Azusa plant were abandoned when the city joined the County Sanitation Districts of Los Angeles County, and sludge from the primary and secondary clarifiers is discharged to the outfall sewer.

Pomona Tri-Cities Sewage Treatment Plant

The operation of this plant is an example of reclamation of water from sewage for the irrigation of crops, and recharge of ground water basins. This activated sludge plant was constructed to treat sewage from the Cities of Pomona, Claremont, and La Verne, and was placed in operation in June 1926. Although the plant capacity was adequate in early years, continued development of the sewered area overloaded the treatment plant facilities and in 1954 the plant was integrated into the sewerage system of the County Sanitation Districts of Los Angeles County. A trunk sewer was constructed to provide the area with access to an ocean outfall; however, operation of the sewage treatment plant as a water reclamation plant to provide for irrigation requirements was continued. A system of trunk sewers was so constructed that certain industrial wastes, produced by industrial developments within the area originally served by the treatment plant and adversely affecting the mineral quality of the treatment plant effluent, bypassed the treatment plant. Sludge digestion facilities at the treatment plant were abandoned upon completion of the trunk sewers and the sludge is now discharged to the trunk sewer which bypasses the plant.

The effluent from the plant has been used for irrigation of crops and recharge of ground water basins since the plant was placed in operation. During the first two years of operation effluent was discharged to San Jose Creek, and from 1928 through 1936 all effluent was used by the Northside Water Company for direct irrigation of citrus orchards and pasture lands. Since 1936 a portion of the effluent has been used by the Northside Water Company and the Diamond Bar Ranch for irrigating citrus orchards and pasture land and the remainder is discharged to San Jose Creek. The portion used for irrigation has steadily decreased in recent years and the amount discharged to San Jose Creek and subsequently percolated to ground water basins has increased. During fiscal 1959-60 about 5,150 acre-feet of sewage were treated at the plant, of which about 450 acre-feet were used for irrigation, and about 4,700 acre-feet were discharged to San Jose Creek.

Kaiser Steel Corporation

The water supply system of this corporation's large steel mill located at Fontana, California, is an excellent example of maximum industrial re-use of water. The water supply for the plant is obtained primarily from wells extracting water from a ground water basin which is seriously overdrawn. The mill is located in an inland valley and there is no available outfall for ocean disposal of wastes. For these reasons, considerable attention was given to conservation of water in the design of the plant.

The water used in the plant is first lime softened with alum and sodium aluminate is added to improve turbidity control. The water is then introduced into the plant which has approximately six separate water systems, wherein the water is recycled and re-used. The water is first used in those operations requiring high quality water such as the open hearth and cooling towers, later in operations which have less rigid water quality requirements such as steel descaling operations and gas washing towers, and finally for quenching coke and cooling slag in the slag pits, which uses have no quality requirements. Additional treatment of the waste water is provided as required during the recycling operations.

The makeup water is approximately one percent of the total flow through the plant, or in other words, water is re-used an average of about 100 times in the plant. The domestic sewage of the plant is treated by sedimentation and trickling filters and the effluent is re-used in the plant.

City of Baltimore Sewage Effluent

The use of water reclaimed from the City of Baltimore sewage effluent by the Bethlehem Steel Company at Sparrows Point, Maryland, is an example of direct industrial use of water reclaimed from sewage. Reclaimed sewage is utilized by the company in its plant process for cooling tower makeup, cooling rolling equipment, quenching coke, and descaling.

Depletion of underground water supplies and accompanying salt water intrusion into these supplies forced the company to develop a new source of water supply. After a survey of all available means of developing a new water supply, it was decided to reclaim water from the City of Baltimore's sewage.

The company originally contracted with the City of Baltimore to take a maximum of 50 million gallons per day of treated sewage; the use of reclaimed sewage commenced in 1942. The successful use of the city's effluent and the continued expansion of the steel plant prompted the company to negotiate a modification of the contract permitting the company to take a maximum of 100 million gallons per day of effluent. The company used about 75 million gallons per day of effluent in 1956.

The City of Baltimore operates two secondary sewage treatment plants which in 1956 had a total average flow of about 130 million gallons per day. The larger of the two is a trickling filter plant and treats about 80 percent of the city's sewage flow. The smaller one is an activated sludge treatment plant and treats about 20 percent of the city's sewage flow.

The company found that the effluent required continuous chlorination. Initially, a dosage of about five parts per million was used, but by 1956 this dosage was reduced to about 2.3 parts per million. Chemical precipitation of the sewage effluent from the trickling filter plant was initially required, but by 1956 this treatment was discontinued.

The company constructed all of the works necessary for the regulation and distribution of the reclaimed water. Facilities initially provided include a 24,300 foot, 60-inch diameter main conduit, a 70-million gallon surface storage reservoir, a completely independent industrial water supply system within the plant, and chlorination facilities. Additional facilities subsequently constructed include a five mile, 96-inch diameter conduit and 42 million gallons of storage capacity.

Some difficulties were experienced in controlling the chloride concentrations in the reclaimed water. These problems were overcome by eliminating a number of the more mineralized sewage discharges from the city's sewers and by rejecting some of the more mineralized sewage flows at the city's treatment plants.

The bacterial quality of the reclaimed water distributed in the plant has been consistently negative for coliform organisms in one milliliter portions and often negative in five milliliter portions.

APPENDIX C

DEFINITIONS

APPENDIX C

DEFINITIONS

In this report, certain words or terms have been assigned specific meanings as follows:

Applied water. The water delivered to a farmer's headgate in the case of irrigation use or to an individual's meter in the case of urban use or its equivalent. It does not include direct precipitation.

Aquifer. A geologic formation, group of formations, or part of a formation that transmits water in sufficient quantity to supply pumping wells or springs.

Biochemical oxygen demand. The amount of oxygen in parts per million required by living organisms during a five-day period in stabilizing decomposable organic matter under aerobic condition at a temperature of 20 degrees centigrade.

Brackish water. Water containing more than 1,500 and less than 10,000 parts per million of total dissolved solids.

Complete mineral analysis. A determination of the concentrations of the principal dissolved constituents in water, namely: calcium, magnesium, sodium, potassium, hydroxide, bicarbonate, carbonate, chloride, sulfate, nitrate, boron, and fluoride. In addition, such an analysis includes determinations of total dissolved solids, electrical conductivity, and pH.

Complete sewage treatment. Combined sedimentation and biological treatment of sewage which produces a clear, stable and well-oxidized effluent.

Confined ground water. A body of ground water overlain by material sufficiently impervious to sever free hydraulic connection with overlying water, and moving under pressure caused by the difference in head between the intake or forebay area and the discharge area of the confined water body.

Consumptive use. The water lost to the atmosphere through the process of evaporation or transpiration, and the water consumed in building plant tissue or by urban types of land use.

Contamination. Defined in Section 13005 of the California Water Code: "an impairment of the quality of the waters of the State by sewage or industrial waste to a degree which creates an actual hazard to public health through poisoning or through the spread of disease . . ." Jurisdiction over matters regarding contamination rests with the State Department of Health and local health officers.

Electrical conductance. The reciprocal of the resistance in ohms measured between opposite faces of a centimeter cube of an aqueous solution at a temperature of 25 degrees centigrade.

Free or unconfined ground water. A body of ground water in the zone of saturation not confined beneath an impervious formation and moving under control of the water table slope.

Incidental reclamation. A process wherein the recovery of waste waters for beneficial use is secondary to sewage treatment or disposal.

Industrial waste. Defined in Section 13005 of the California Water Code: "any and all liquid or solid waste substance, not sewage, from any producing, manufacturing or processing operation of whatever nature".

Involuntary reclamation. The recovery of waste waters for beneficial use which have lost their identity through mixing with natural stream flow or ground water to which they were discharged in the process of final disposal.

Nuisance. Defined in Section 13005 of the California Water Code: "damage to any community by odors or unsightliness resulting from unreasonable practices in the disposal of sewage or industrial wastes". Regional Water Pollution Control Boards are responsible for prevention and abatement of nuisance.

pH. The logarithm, to the base 10, of the reciprocal of the hydrogen-ion concentration, or more precisely, of the hydrogen-ion activity, in moles per liter.

Planned reclamation. Any process of recovery of water from waste waters that was originally conceived and planned for the primary purpose of putting the recovered water to beneficial use.

Pollution. Defined in Section 13005 of the California Water Code: "an impairment of the quality of the waters of the State by sewage or industrial waste to a degree which does not create an actual hazard to the public health but which does adversely and unreasonably affect such waters for domestic, industrial, agricultural, navigational, recreational or other beneficial use, or which does adversely and unreasonably affect the ocean waters and bays of the State devoted to public recreation". Regional Water Pollution Control Boards are responsible for prevention and abatement of pollution.

Primary sewage treatment. Any process which removes a portion of the suspended and floating matter from sewage or industrial waste by screening, skimming, sedimentation, or other physical means.

Reclaimed water. Water recovered from sewage and/or industrial waste that is put to beneficial use or is held available for beneficial purposes.

Reclamation. The process of recovering water from sewage or industrial waste so that the water may be used for beneficial purposes.

Salt balance. The relationship of salt input to salt output. For example: to maintain usable quality of ground water, it is necessary to maintain a favorable salt balance where the total mass of dissolved salts entering a ground water basin from all sources of recharge is less than the total mass of dissolved salts removed from the basin by natural outflow and exported extractions.

Sanitary quality. Refers to the organic biological content of waste waters: sanitary analyses used in the report include determinations of biochemical oxygen demand (B.O.D.), suspended and settleable solids, volatile dissolved solids, and grease.

Secondary sewage treatment. Any process of sewage or industrial waste treatment which follows primary or intermediate treatment, and which accomplishes further stabilization of organic matter by biological or chemical action.

Sewage. Defined in Section 13005 of the California Water Code: "any and all waste substance, liquid or solid, associated with human habitation, or which contains or may be contaminated with human or animal excreta or excrement, offal, or any feculent matter". As used in this report, sewage is included as part of the waste waters carried by community sewer systems.

Percent sodium. The equivalents per million of sodium times 100 divided by the sum of the equivalents per million of calcium, magnesium, sodium, and potassium.

Trace metal analysis. A determination of the concentrations of certain of the dissolved constituents that are likely to be found in limited amounts in water. Such constituents include: copper, aluminum, manganese, hexavalent chromium, iron, lead, zinc, arsenic, and tin. Generally, only minute quantities of these constituents exist in naturally occurring waters.

Ultimate. This refers to an unspecified but long period of years in the future when land use and water supply development will be at a maximum and essentially stabilized.

Waste water. The water that has been put to some use or uses and has been disposed of, commonly to a sewer or wasteway. It may be liquid industrial waste or sewage or both.

Water requirement. The water needed to provide for all beneficial uses, whether consumptive or nonconsumptive, and for irrecoverable losses incidental to such uses.

APPENDIX D

DETAILED COST ESTIMATES

APPENDIX D

DETAILED COST ESTIMATES

TABLE D-1

ESTIMATED COST OF HYPERION
RECLAMATION PLANT

(Based on prices prevailing in 1960)

Capacity of plant: 160 cubic feet per second
Annual yield: 116,000 acre-feet

Item	Cost
CAPITAL COSTS	
Water reclamation plant, secondary facilities only	$ 9,300,000
Land and improvements	250,000
Subtotal	$ 9,550,000
Administration, engineering, and contingencies, 30 percent	$ 2,860,000
Interest during construction	480,000
TOTAL	$12,890,000
ANNUAL COSTS	
Interest, 4 percent	$ 516,000
Amortization, 40-year sinking fund at 4 percent	136,000
Operation and maintenance	580,000
TOTAL	$ 1,232,000

TABLE D-2

ESTIMATED COST OF CONDUIT FROM HYPERION
TREATMENT PLANT TO VERNON SERVICE AREA

(Based on prices prevailing in 1960)

Capacity of conduit: 75 and 25 cubic feet per second   Length of conduit: 24.9 miles

Annual yield: 45,000 acre-feet

Item	Quantity	Unit price	Cost	
CAPITAL COSTS				
Pipe line				
Excavation, unclassified	355,000 cu.yd.	$ 3.40	$1,207,000	
Backfill, unclassified	244,000 cu.yd.	1.40	342,000	
Backfill, sand	27,900 cu.yd.	3.50	97,600	
Pipe, reinforced concrete, furnish and install,				
54-inch diameter, main line	85,500 lin.ft.	35.20	3,010,000	
36-inch diameter, Vernon	13,500 lin.ft.	15.60	211,000	
33-inch diameter, East L.A.	32,500 lin.ft.	13.90	452,000	
Fittings			236,000	
Valves			80,400	
Venturi meters			14,000	
Special crossings	2,250 lin.ft.	93.00	209,000	
Road resurfacing	113,000 lin.ft.	3.90	441,000	
Right of way			100,000	$6,400,000
Pumping plants	2 each	300,000.00		600,000
Regulatory reservoirs				450,000
Subtotal				$7,450,000
Administration, engineering, and contingencies, 30 percent				2,235,000
Interest during construction				375,000
TOTAL				$10,060,000

ANNUAL COSTS	
Interest, 4 percent	$ 402,400
Amortization, 40-year sinking fund at 4 percent	105,800
Replacement	7,900
Electrical energy	204,000
Operation and maintenance	90,000
TOTAL	$ 810,100

TABLE D-3

ESTIMATED COST OF CONDUIT FROM HYPERION
RECLAMATION PLANT TO TORRANCE SERVICE AREA

(Based on prices prevailing in 1960)

Capacity of conduit: 29 and 17 cubic feet per second   Length of conduit: 10.4 miles

Annual yield: 17,000 acre-feet

Item	Quantity	Unit price	Cost	
CAPITAL COSTS				
Pipe line				
Excavation, unclassified	86,000 cu.yd.	$ 2.10	$ 181,000	
Backfill, unclassified	63,000 cu.yd.	1.20	75,600	
Backfill, sand	7,000 cu.yd.	2.20	15,400	
Pipe, reinforced concrete, furnish and install				
42-inch diameter	7,000 lin.ft.	24.10	169,000	
30-inch diameter	48,000 lin.ft.	11.20	538,000	
Fittings			50,000	
Valves			48,000	
Meters			10,000	
Road resurfacing	29,100 lin.ft.	3.20	93,000	
Right of way			90,000	$1,270,000
Pumping plant	1 each	100,000.00		100,000
Subtotal				$1,370,000
Administration, engineering, and contingencies, 30 percent				$ 411,000
Interest during construction				34,000
TOTAL				$1,815,000
ANNUAL COSTS				
Interest, 4 percent				$ 72,600
Amortization, 40-year sinking fund at 4 percent				19,100
Replacement				1,400
Electrical energy				36,800
Operation and maintenance				26,000
TOTAL				$ 155,900

TABLE D-4

ESTIMATED COST OF WHITTIER
NARROWS RECLAMATION PLANT

(Based on prices prevailing in 1960)

Capacity of plant: 120 cubic feet per second*
Annual yield: 72,000 acre-feet

Item	Cost
CAPITAL COSTS	
Water reclamation plant	$10,800,000
Lands and improvements	300,000
Subtotal	$11,100,000
Administration, engineering, and contingencies, 30 percent	$ 3,330,000
Interest during construction	555,000
TOTAL	$14,985,000
ANNUAL COSTS	
Interest, 4 percent	$ 599,400
Amortization, 40-year sinking fund at 4 percent	157,600
Operation and maintenance	590,000
TOTAL	$ 1,347,000

* Average period of operation, 10 months per year

TABLE D-5

ESTIMATED COST OF CONDUIT FROM JOINT OUTFALL "B"
TO WHITTIER NARROWS RECLAMATION PLANT

(Based on prices prevailing in 1960)

Capacity of conduit: 60 cubic feet per second   Length of conduit: 2.8 miles

Annual yield: 26,000 acre-feet

Item	Quantity	Unit price	Cost	
CAPITAL COSTS				
Pipe line				
Excavation, unclassified	35,700 cu.yd.	$ 1.00	$ 35,700	
Backfill, unclassified	26,100 cu.yd.	0.60	15,700	
Pipe, reinforced concrete, furnish and install, 48-inch diameter	15,000 lin.ft.	26.80	402,000	
Fittings			21,000	
Valves and meters			25,000	
Special crossings			41,000	
Manholes	16 each	620.00	9,900	$ 550,300
Diversion structure				12,700
Subtotal				$ 563,000
Administration, engineering, and contingencies, 30 percent				$ 169,000
Interest during construction				7,000
TOTAL				$ 739,000
ANNUAL COSTS				
Interest, 4 percent				$ 29,600
Amortization, 40-year sinking fund at 4 percent				7,800
Operation and maintenance				4,000
TOTAL				$ 41,400

TABLE D-6

ESTIMATED COST OF CONDUIT FROM GLENDALE OUTFALL SEWER TO WHITTIER NARROWS RECLAMATION PLANT

(Based on prices prevailing in 1960)

Capacity of conduit: 100 cubic feet per second

Length of conduit: 8.9 miles

Annual yield: 46,000 acre-feet

Item	Quantity	Unit price	Cost	
CAPITAL COSTS				
Pipe line				
Excavation, unclassified	194,000 cu.yd.	$ 3.40	$ 660,000	
Backfill, unclassified	121,000 cu.yd.	1.30	157,000	
Backfill, sand	15,600 cu.yd.	2.20	34,300	
Pipe, reinforced concrete, furnish and install,				
72-inch diameter	26,200 lin.ft.	37.40	980,000	
66-inch diameter	17,000 lin.ft.	27.80	473,000	
Tunnel	3,800 lin.ft.	280.00	1,066,000	
Fittings			106,000	
Valves			55,000	
Venturi meter	1 each	25,000.00	25,000	
Manholes	44 each	620.00	27,200	
Special crossings	210 lin.ft.	160.00	33,500	
Road surfacing	34,000 lin.ft.	4.30	146,000	
Right of way			45,000	$3,808,000
Diversion struction				19,000
Subtotal				$3,827,000
Administration, engineering, and contingencies, 30 percent				$1,148,000
Interest during construction				95,000
TOTAL				$5,070,000
ANNUAL COSTS				
Interest, 4 percent				$ 202,800
Amortization, 40-year sinking fund at 4 percent				53,300
Operation and maintenance				15,000
TOTAL				$ 271,100

TABLE D-7

ESTIMATED COST OF CONDUIT FROM SOUTH WHITTIER OUTFALL SEWER TO WHITTIER NARROWS RECLAMATION PLANT

(Based on prices prevailing in 1960)

Capacity of conduit: 14 cubic feet per second
Length of conduit: 8.9 miles
Annual yield: 4,400 acre-feet

Item	Quantity	Unit price	Cost	
CAPITAL COSTS				
Pipe line				
Excavation	52,700 cu.yd.	$ 2.60	$ 137,000	
Sand backfill	3,900 cu.yd.	3.10	12,100	
Backfill	40,900 cu.yd.	1.20	49,100	
Pipe, reinforced concrete, furnish and install, 24-inch diameter	47,000 lin.ft.	10.20	479,400	
Fittings			30,000	
Valve and meter			15,400	
Special crossings	730 lin.ft.	25.00	18,200	
Road resurfacing	38,000 lin.ft.	1.60	60,800	
Right of way			50,000	$ 852,000
Pumping plant	2 each	65,000.00		130,000
Diversion structure				25,000
Subtotal				$1,007,000
Administration, engineering, and contingencies, 30 percent				302,000
Interest during construction				25,000
TOTAL				$1,334,000
ANNUAL COSTS				
Interest, 4 percent				$ 53,400
Amortization, 40-year sinking fund at 4 percent				14,000
Replacement				4,400
Electrical energy				14,300
Operation and maintenance				13,000
TOTAL				$ 99,100

TABLE D-8

ESTIMATED COST OF SOUTH
WHITTIER RECLAMATION PLANT

(Based on prices prevailing in 1960)

Capacity of plant: 7 cubic feet per second*
Annual yield: 4,400 acre-feet

Item	Cost
CAPITAL COSTS	
Water reclamation plant	$ 1,100,000
Division structure	12,000
Land and improvements	50,000
Subtotal	$ 1,162,000
Administration, engineering, and contingencies, 30 percent	$ 355,000
Interest during construction	30,000
TOTAL	$ 1,547,000
ANNUAL COSTS	
Interest, 4 percent	$ 61,900
Amortization, 40-year sinking fund at 4 percent	16,300
Operation and maintenance	84,000
TOTAL	$ 162,200

* Period of operation, 10 months per year

TABLE D-9

ESTIMATED COST OF VALLEY
RECLAMATION PLANT

(Based on prices prevailing in 1960)

Capacity of plant: 5 cubic feet per second
Annual yield: 3,000 acre-feet

Item	Cost
CAPITAL COSTS	
Water reclamation plant	$ 843,000
Administration, engineering, and contingencies, 30 percent	253,000
Interest during construction	21,000
TOTAL	$ 1,117,000
ANNUAL COSTS	
Interest, 4 percent	$ 44,700
Amortization, 40-year sinking fund at 4 percent	11,700
Operation and maintenance	67,000
TOTAL	$ 123,400

TABLE D-10

ESTIMATED COST OF CONDUITS FROM VALLEY RECLAMATION PLANT TO GRIFFITH PARK SERVICE AREA

(Based on prices prevailing in 1960)

Capacity of conduits: 1 and 4 cubic feet per second   Length of conduits: 2.7 miles

Annual yield: 3,000 acre-feet

Item	Quantity	Unit price	Cost	
CAPITAL COSTS				
Pipe line				
Excavation	8,800 cu.yd.	$ 1.00	$ 8,800	
Backfill	5,900 cu.yd.	0.40	2,400	
Pipe, reinforced concrete, furnished and installed				
15-inch diameter	9,000 lin.ft.	6.60	59,400	
8-inch diameter	5,000 lin.ft.	4.00	20,000	
Fittings			4,300	
Valves and meter			12,000	$ 106,900
Pumping plant				25,000
Subtotal				$ 131,900
Administration, engineering, and contingencies, 30 percent				39,500
Interest during construction				1,600
TOTAL				$ 173,000
ANNUAL COSTS				
Interest, 4 percent				$ 6,900
Amortization 40-year sinking fund at 4 percent				1,800
Operation and maintenance				6,000
TOTAL				$ 14,700

PLATE I

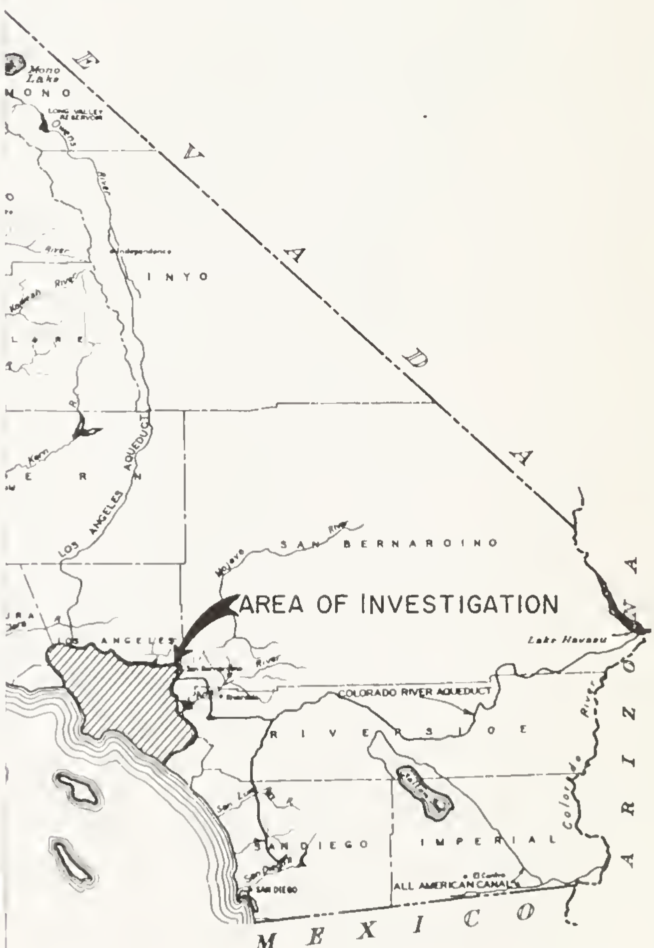
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT

BILITY OF RECLAMATION OF WATER FROM WASTES
IN
THE LOS ANGELES METROPOLITAN AREA

CATION OF AREA OF INVESTIGATION

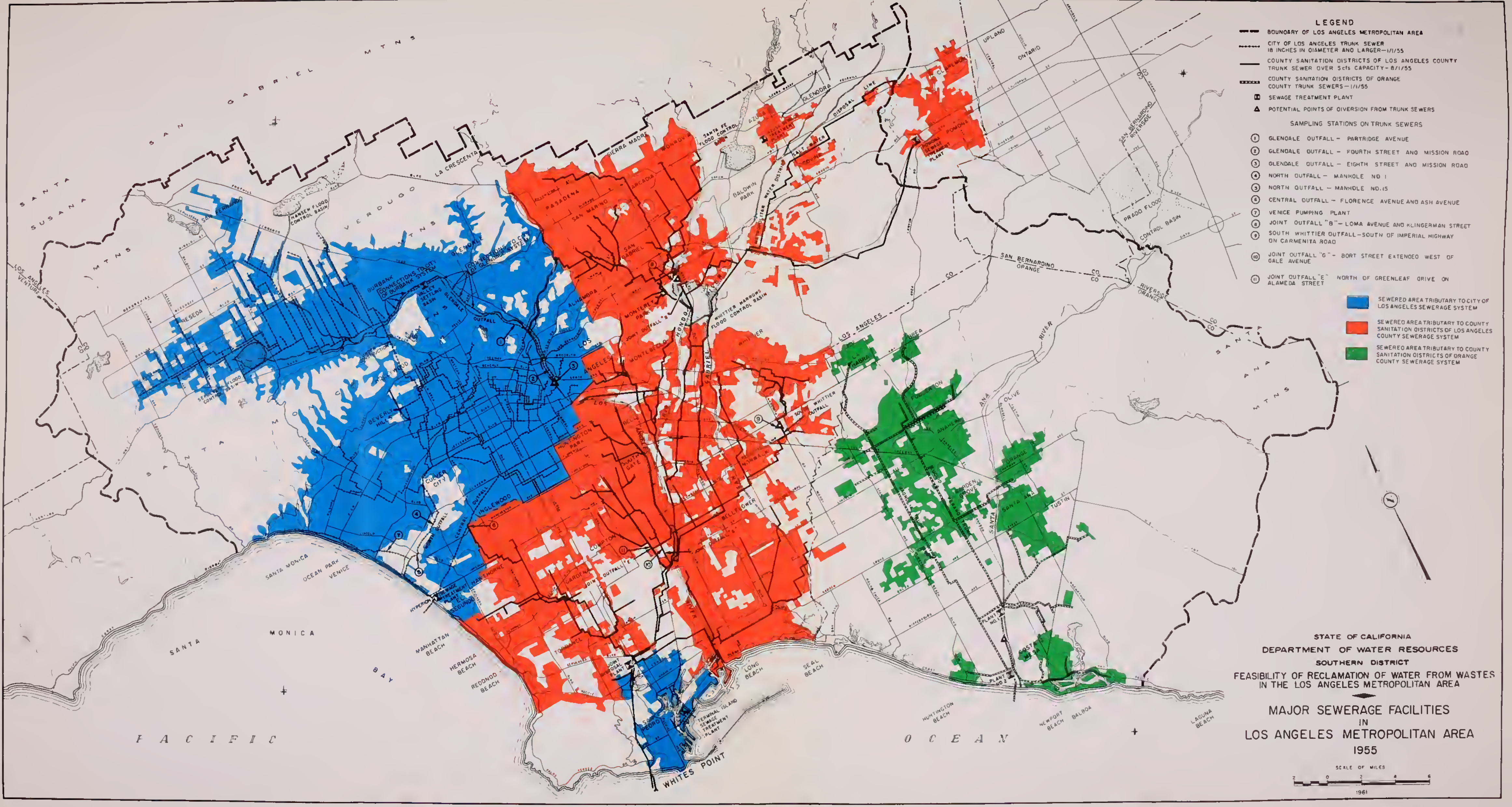
SCALE OF MILES
40 0 40 80

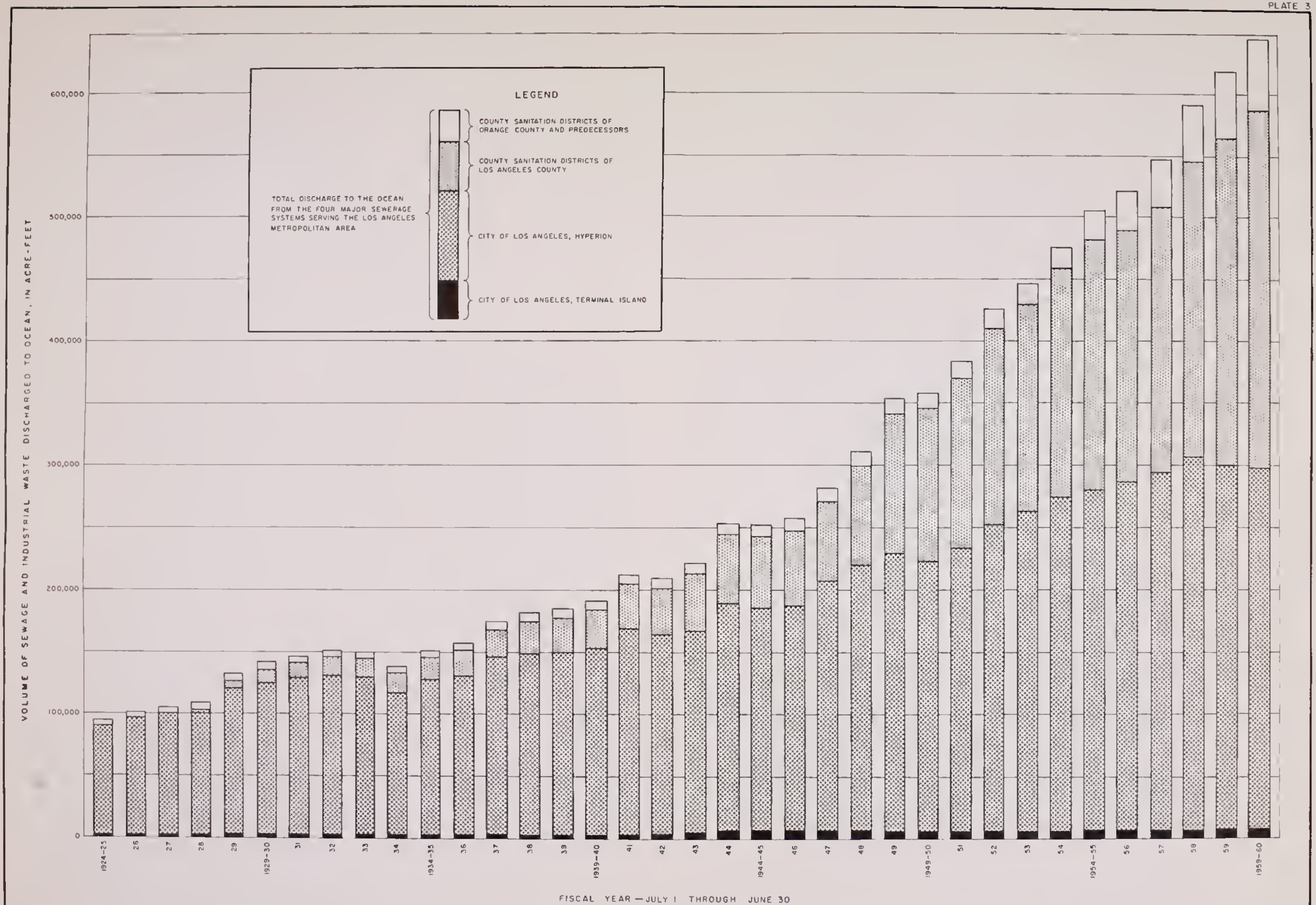
1961




STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT
FEASIBILITY OF RECLAMATION OF WATER FROM WASTES
IN
THE LOS ANGELES METROPOLITAN AREA
LOCATION OF AREA OF INVESTIGATION
SCALE OF MILES
40 0 40 80
1961
OREGON
NEVADA
ARIZONA
MEXICO
PACIFIC OCEAN
AREA OF INVESTIGATION
SISKIYOU
MODOC
HUMBOLDT
TRINITY
SHASTA
LASSEN
TEHAMA
PLUMAS
MENDOCINO
GLENN
BUTTE
SIERRA
COLUSA
LAKE
SONOMA
YOLO
ALPINE
SOLANO
MARIN
CONTRA COSTA
SAN FRANCISCO
OAKLAND
ALAMEDA
TUOLUMNE
MONO
SANTA CLARA
INYO
SAN BENITO
MONTEREY
KINGS
TULARE
SAN LUIS OBISPO
KERN
SANTA BARBARA
VENTURA
LOS ANGELES
SAN BERNARDINO
RIVERSIDE
SAN DIEGO
IMPERIAL
COLORADO RIVER AQUEDUCT
ALL AMERICAN CANAL
LOS ANGELES AQUEDUCT
Shasta Reservoir
Eagle Lake
Honey Lake
Lake Almanor
Clear Lake
Lake Tahoe
Mono Lake
Millerton Lake
Lake Havasu
Goose Lake
N

PLATE 2

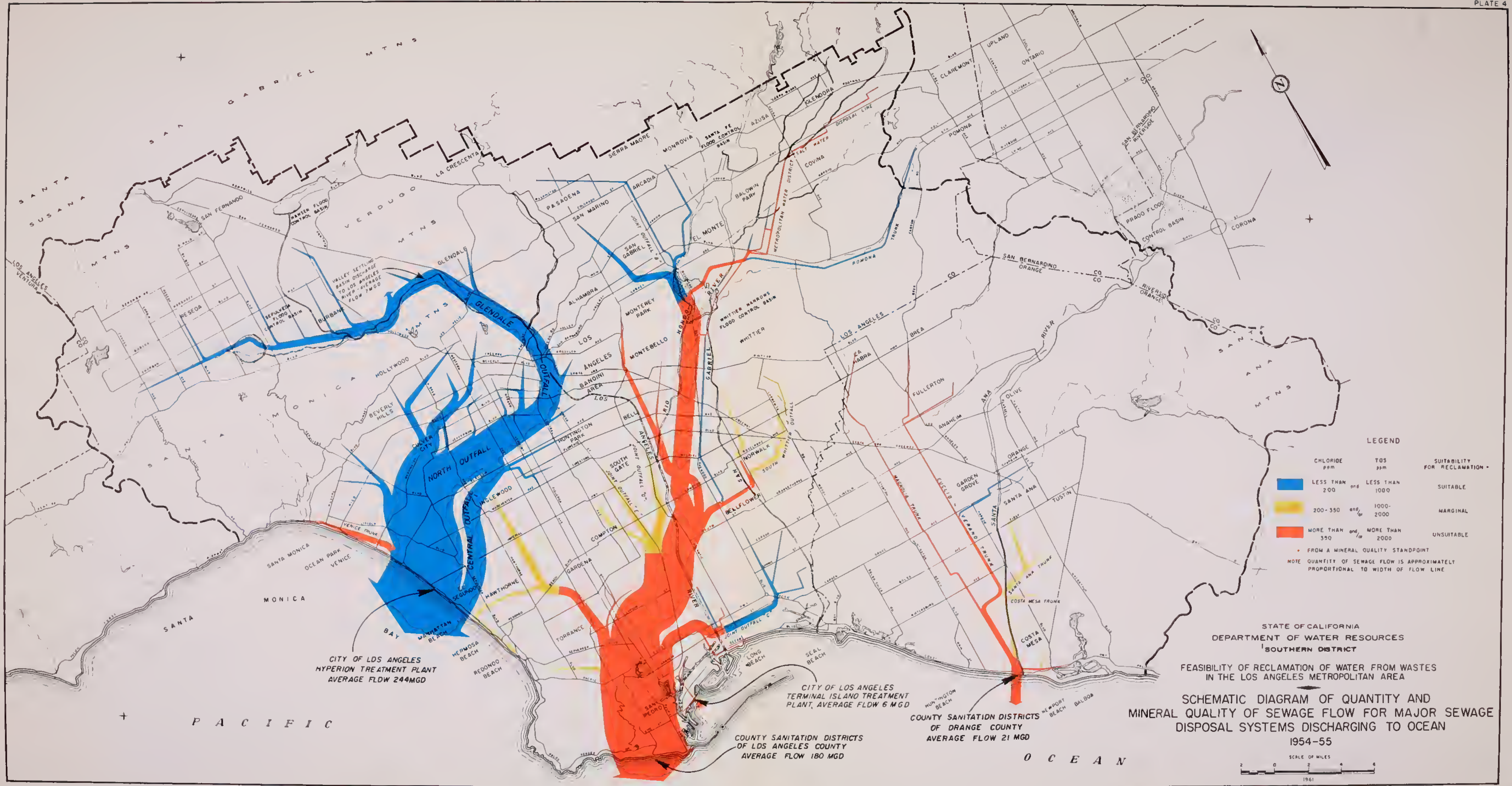

LEGEND
BOUNDARY OF LOS ANGELES METROPOLITAN AREA
CITY OF LOS ANGELES TRUNK SEWER 18 INCHES IN DIAMETER AND LARGER—1/1/55
COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY TRUNK SEWER OVER 5cfs CAPACITY—8/1/55
COUNTY SANITATION DISTRICTS OF ORANGE COUNTY TRUNK SEWERS—1/1/55
SEWAGE TREATMENT PLANT
POTENTIAL POINTS OF DIVERSION FROM TRUNK SEWERS
SAMPLING STATIONS ON TRUNK SEWERS
1 GLENDALE OUTFALL – PARTRIDGE AVENUE
2 GLENDALE OUTFALL – FOURTH STREET AND MISSION ROAD
3 GLENDALE OUTFALL – EIGHTH STREET AND MISSION ROAD
4 NORTH OUTFALL – MANHOLE NO 1
5 NORTH OUTFALL – MANHOLE NO.15
6 CENTRAL OUTFALL – FLORENCE AVENUE AND ASH AVENUE
7 VENICE PUMPING PLANT
8 JOINT OUTFALL "B" – LOMA AVENUE AND KLINGERMAN STREET
9 SOUTH WHITTIER OUTFALL – SOUTH OF IMPERIAL HIGHWAY ON CARMENITA ROAD
10 JOINT OUTFALL "G" – BORT STREET EXTENDED WEST OF GALE AVENUE
11 JOINT OUTFALL "E" NORTH OF GREENLEAF DRIVE ON ALAMEDA STREET
SEWERED AREA TRIBUTARY TO CITY OF LOS ANGELES SEWERAGE SYSTEM
SEWERED AREA TRIBUTARY TO COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY SEWERAGE SYSTEM
SEWERED AREA TRIBUTARY TO COUNTY SANITATION DISTRICTS OF ORANGE COUNTY SEWERAGE SYSTEM
PACIFIC
OCEAN
SANTA MONICA BAY
WHITES POINT
SAN GABRIEL MTNS
SANTA SUSANA MTNS
VERDUGO MTNS
SANTA MONICA MTNS
SANTA ANA MTNS
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT
FEASIBILITY OF RECLAMATION OF WATER FROM WASTES IN THE LOS ANGELES METROPOLITAN AREA
MAJOR SEWERAGE FACILITIES
IN
LOS ANGELES METROPOLITAN AREA
1955
SCALE OF MILES
1961

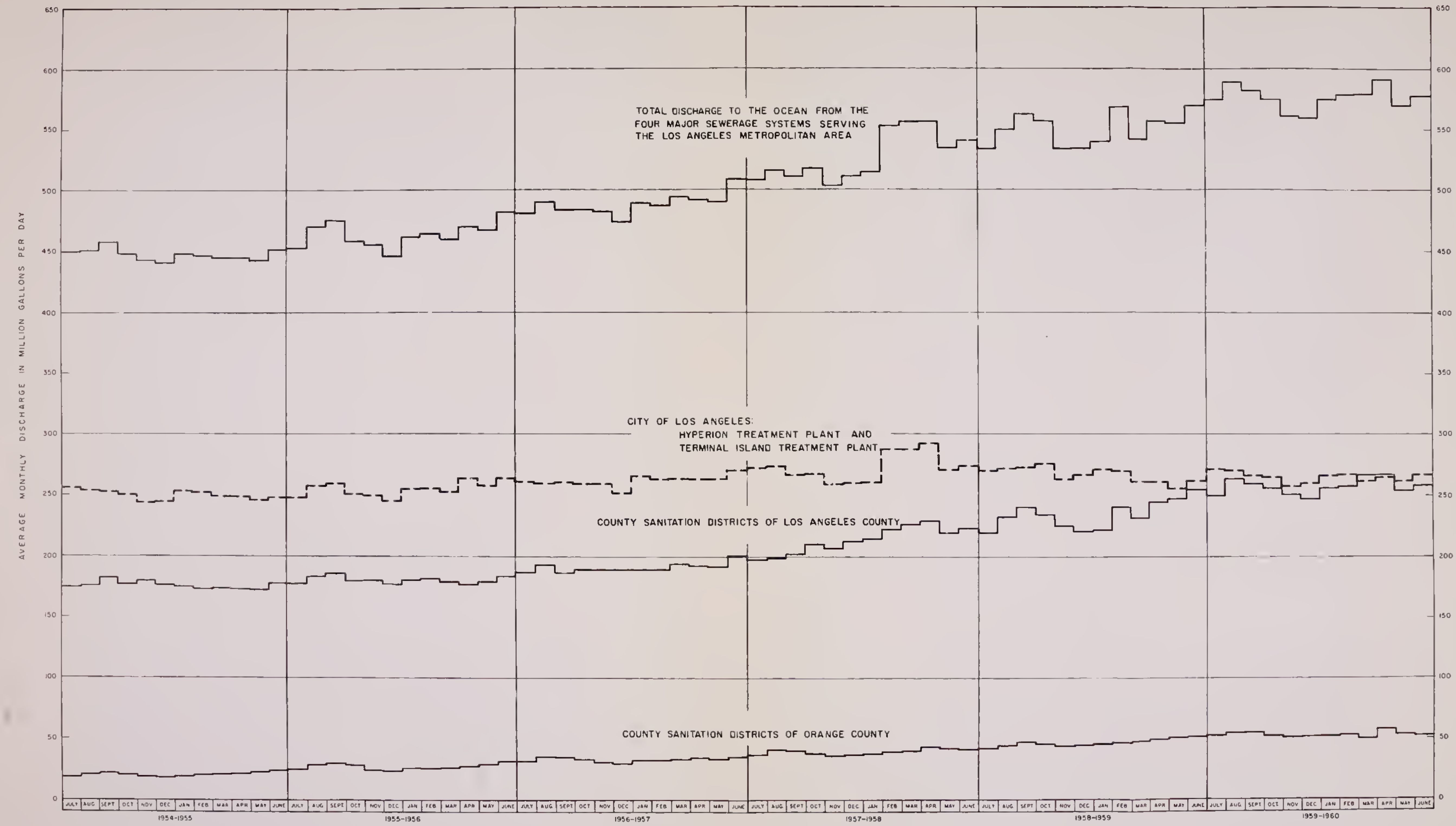


HISTORICAL DISCHARGE OF SEWAGE AND INDUSTRIAL WASTE TO THE OCEAN FROM THE LOS ANGELES METROPOLITAN AREA

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT 1961

PLATE 4

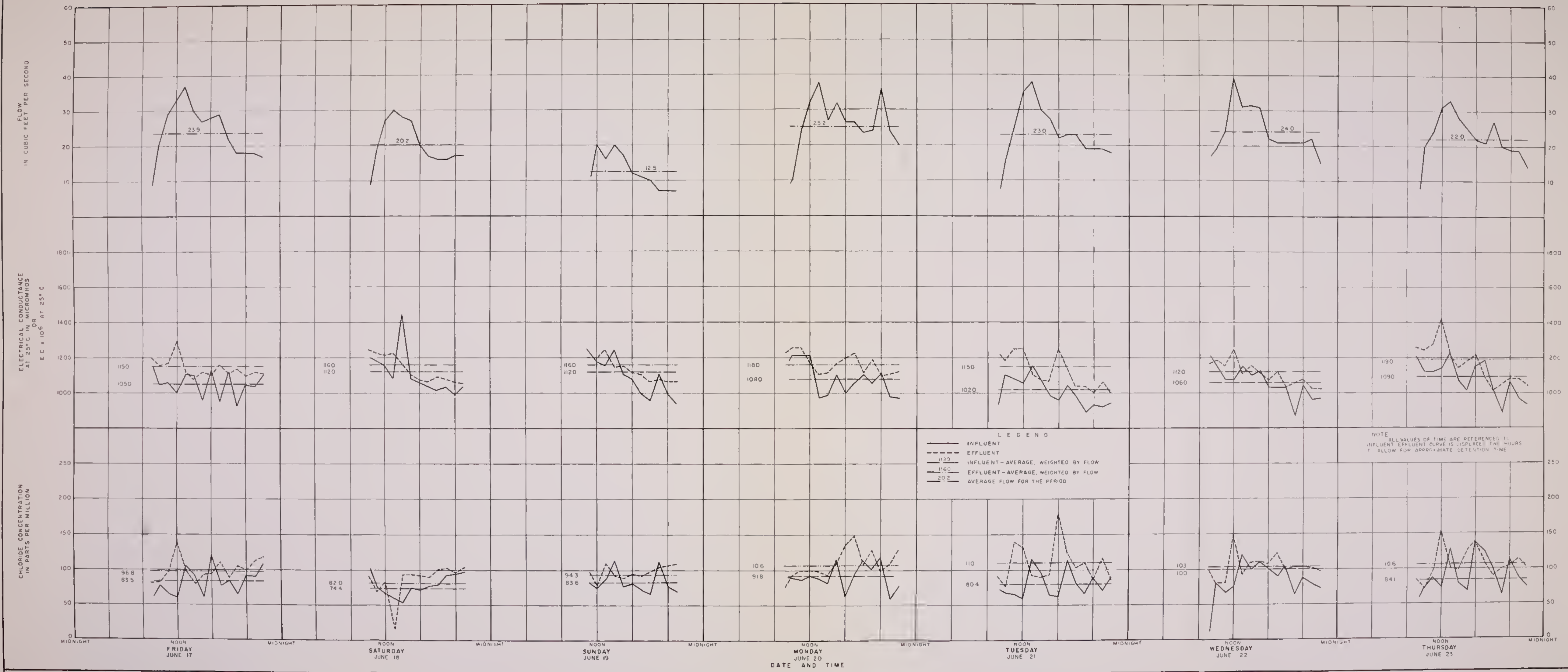

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT
FEASIBILITY OF RECLAMATION OF WATER FROM WASTES IN THE LOS ANGELES METROPOLITAN AREA
SCHEMATIC DIAGRAM OF QUANTITY AND MINERAL QUALITY OF SEWAGE FLOW FOR MAJOR SEWAGE DISPOSAL SYSTEMS DISCHARGING TO OCEAN
1954-55
SCALE OF MILES
1961
LEGEND
CHLORIDE ppm
TDS ppm
SUITABILITY FOR RECLAMATION *
LESS THAN 200 and LESS THAN 1000 SUITABLE
200-350 and/or 1000-2000 MARGINAL
MORE THAN 350 and/or MORE THAN 2000 UNSUITABLE
* FROM A MINERAL QUALITY STANDPOINT
NOTE: QUANTITY OF SEWAGE FLOW IS APPROXIMATELY PROPORTIONAL TO WIDTH OF FLOW LINE
CITY OF LOS ANGELES HYPERION TREATMENT PLANT AVERAGE FLOW 244MGD
CITY OF LOS ANGELES TERMINAL ISLAND TREATMENT PLANT, AVERAGE FLOW 6 MGD
COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY AVERAGE FLOW 180 MGD
COUNTY SANITATION DISTRICTS OF ORANGE COUNTY AVERAGE FLOW 21 MGD
VALLEY SETTLING BASIN DISCHARGE TO LOS ANGELES RIVER - AVERAGE FLOW 7 MGD
NORTH OUTFALL
CENTRAL OUTFALL
GLENDALE OUTFALL
JOINT OUTFALL "B"
JOINT OUTFALL "C"
SALT WATER DISPOSAL LINE
POMONA TRUNK
SANTA ANA TRUNK
COSTA MESA TRUNK
VENICE TRUNK
SAN GABRIEL MTNS
SANTA SUSANA MTNS
SANTA MONICA MTNS
VERDUGO MTNS
SANTA ANA MTNS
SANTA MONICA BAY
PACIFIC OCEAN
LOS ANGELES
SAN FERNANDO
GLENDALE
PASADENA
BURBANK
HOLLYWOOD
BEVERLY HILLS
CULVER CITY
INGLEWOOD
HAWTHORNE
GARDENA
TORRANCE
COMPTON
LONG BEACH
SAN PEDRO
WHITTIER
FULLERTON
ANAHEIM
SANTA ANA
COSTA MESA
POMONA
ONTARIO
CORONA
EL MONTE
MONTEBELLO
MONTEREY PARK
ALHAMBRA
ARCADIA
MONROVIA
AZUSA
GLENDORA
COVINA
SIERRA MADRE
LA CRESCENTA
CLAREMONT
UPLAND
HUNTINGTON BEACH
NEWPORT BEACH
BALBOA
SEAL BEACH
REDONDO BEACH
HERMOSA BEACH
MANHATTAN BEACH
SEGUNDO
VENICE
OCEAN PARK
SANTA MONICA
RESEDA
NORWALK
BELLFLOWER
SOUTH GATE
HUNTINGTON PARK
BELL
TUSTIN
ORANGE
GARDEN GROVE
BREA
LA HABRA
BALDWIN PARK
SAN MARINO
SAN GABRIEL
SAN BERNARDINO CO
ORANGE CO
RIVERSIDE CO
LOS ANGELES CO
VENTURA CO
PRADO FLOOD CONTROL BASIN
SEPULVEDA FLOOD CONTROL BASIN
HANSEN FLOOD CONTROL BASIN
WHITTIER NARROWS FLOOD CONTROL BASIN
SANTA FE FLOOD CONTROL BASIN
LOS ANGELES RIVER
SAN GABRIEL RIVER
RIO HONDO
SANTA ANA RIVER



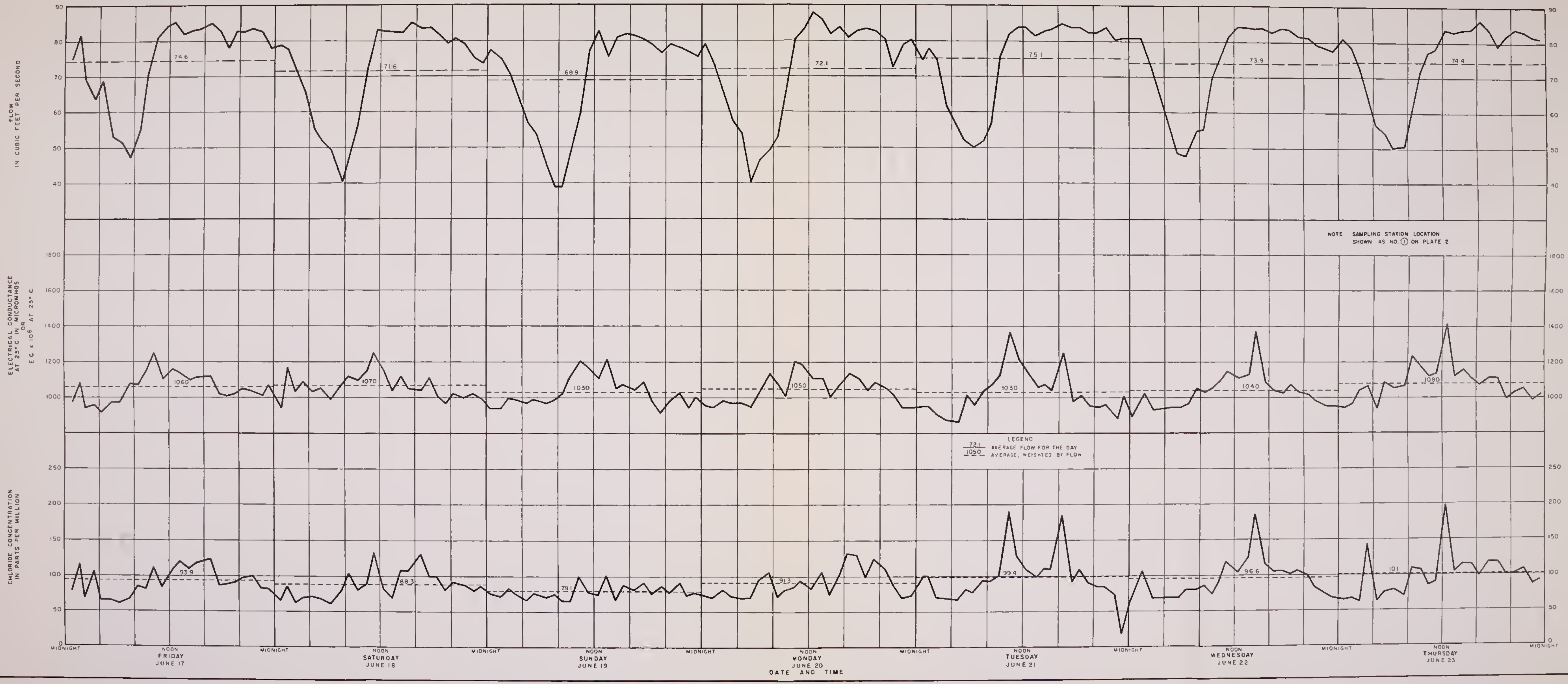
MONTHLY DISCHARGE OF SEWAGE FROM THE LOS ANGELES METROPOLITAN AREA

JULY 1954 THROUGH JUNE 1960

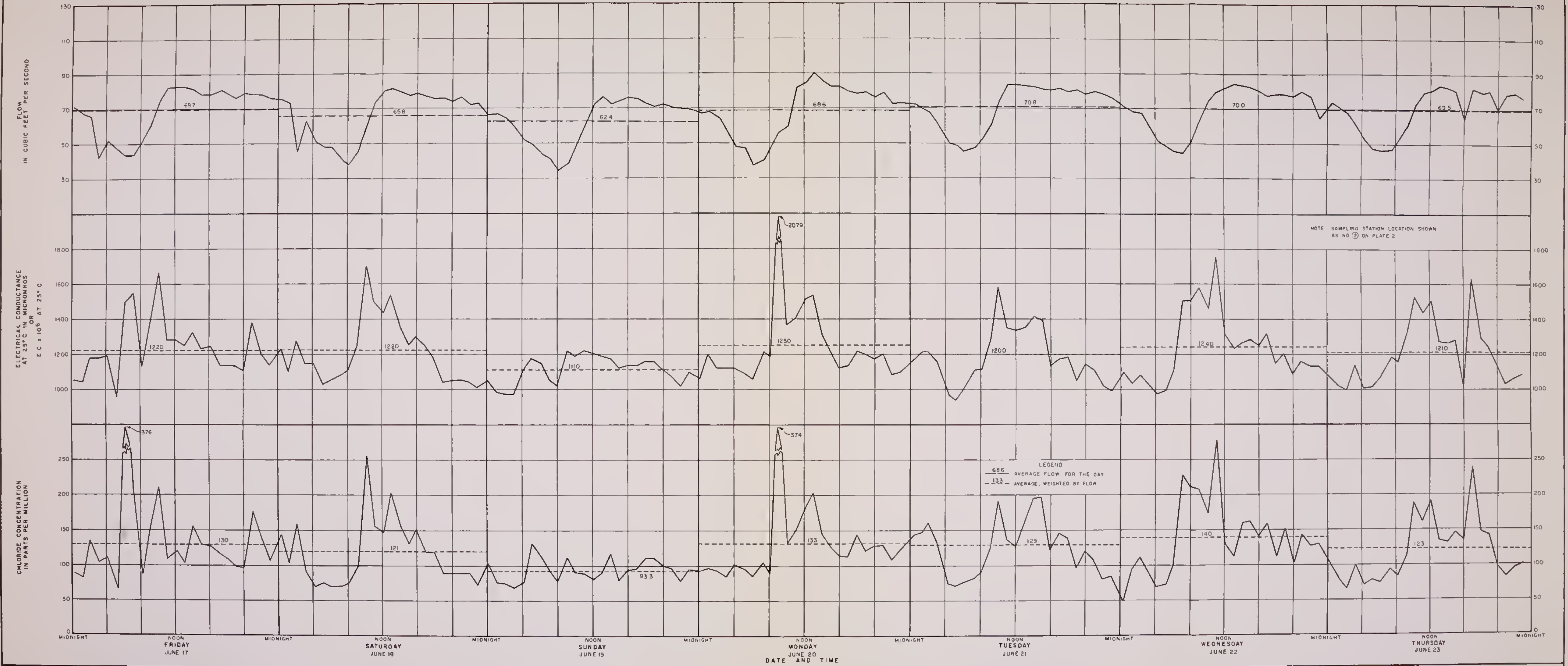
DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT 1961



VARIATIONS IN CHLORIDE CONCENTRATION, ELECTRICAL CONDUCTIVITY, AND FLOW FOR PERIOD JUNE 17 THROUGH JUNE 23, 1955
VALLEY SETTLING BASIN, LOS ANGELES CITY SEWERAGE SYSTEM

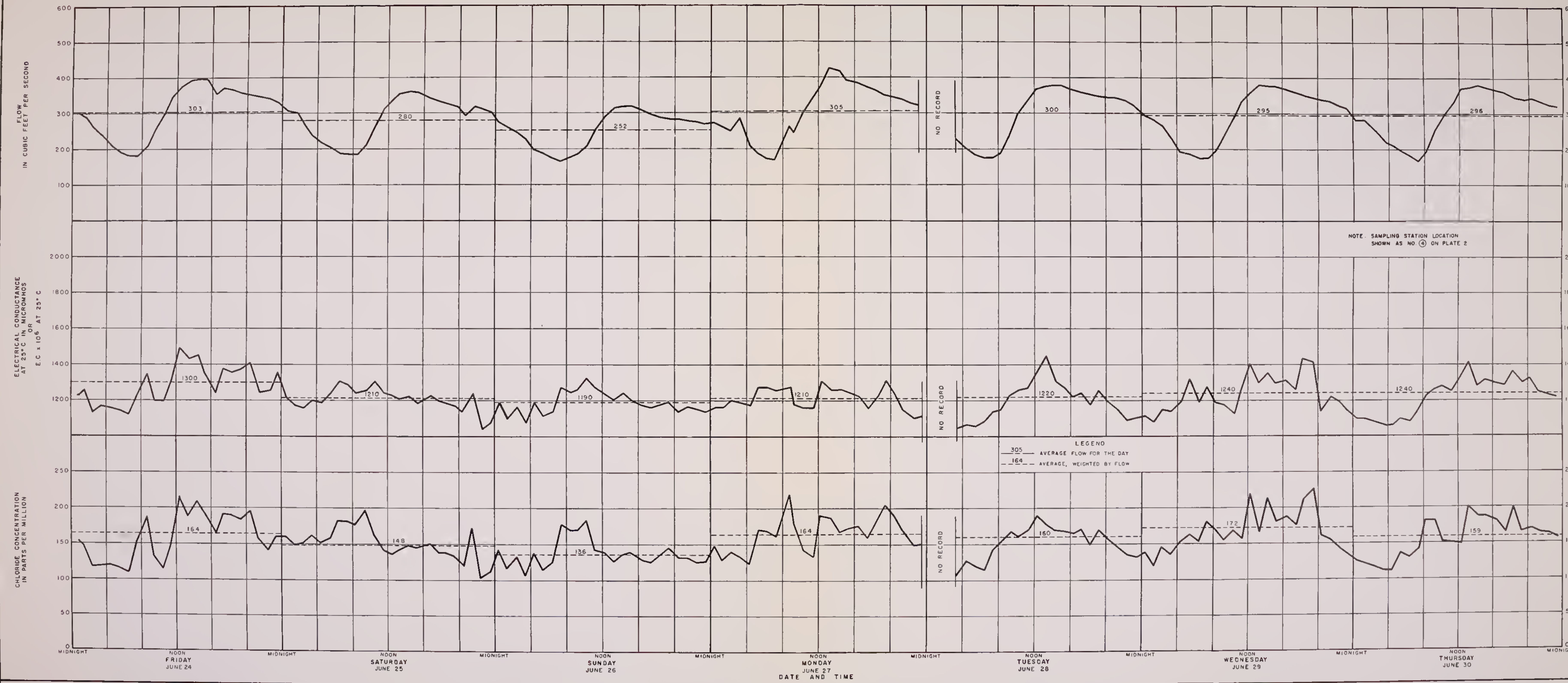


VARIATIONS IN CHLORIDE CONCENTRATION, ELECTRICAL CONDUCTIVITY, AND FLOW FOR PERIOD JUNE 17 THROUGH JUNE 23, 1955
GLENDALE OUTFALL SEWER AT PARTRIDGE AVENUE, LOS ANGELES CITY SEWERAGE SYSTEM



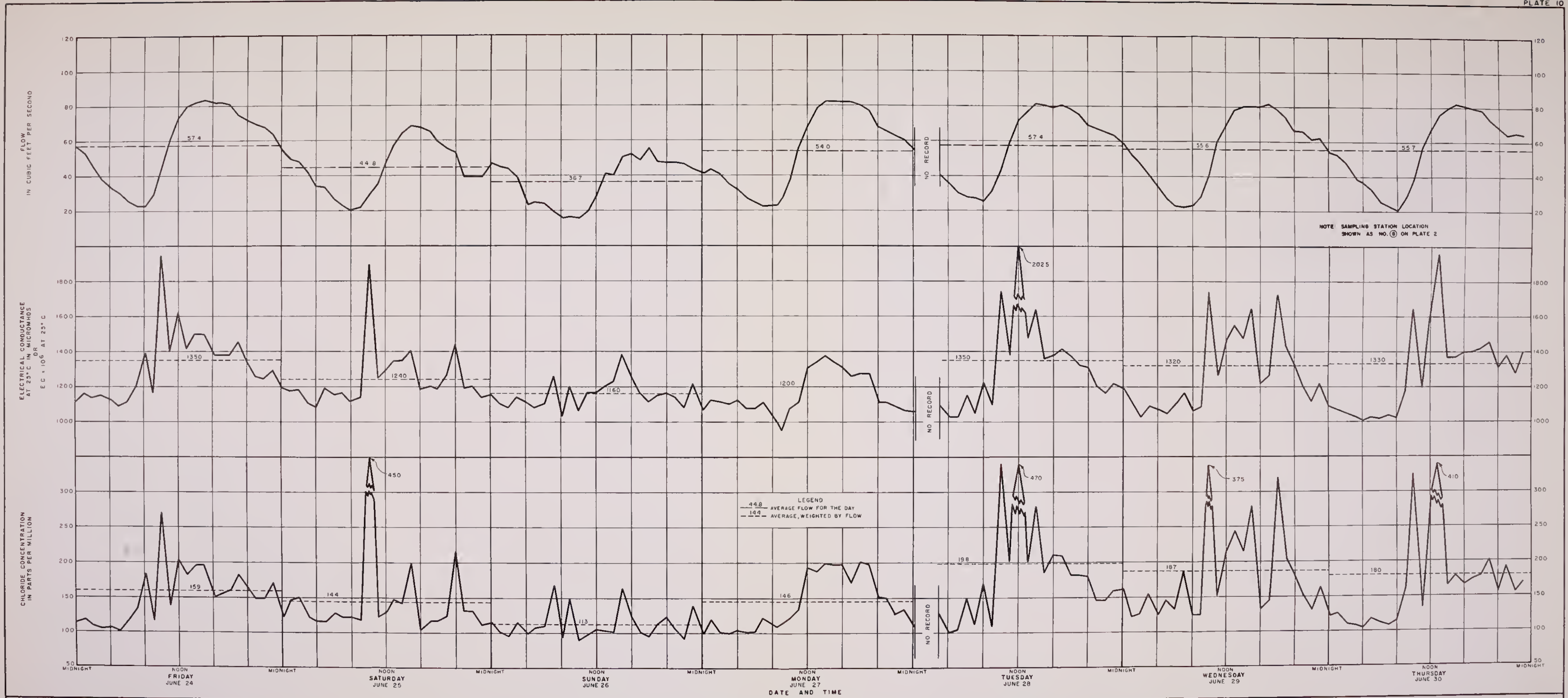
VARIATIONS IN CHLORIDE CONCENTRATION, ELECTRICAL CONDUCTIVITY, AND FLOW FOR PERIOD JUNE 17 THROUGH JUNE 23, 1955

GLENDALE OUTFALL SEWER AT FOURTH STREET AND MISSION ROAD, LOS ANGELES CITY SEWERAGE SYSTEM



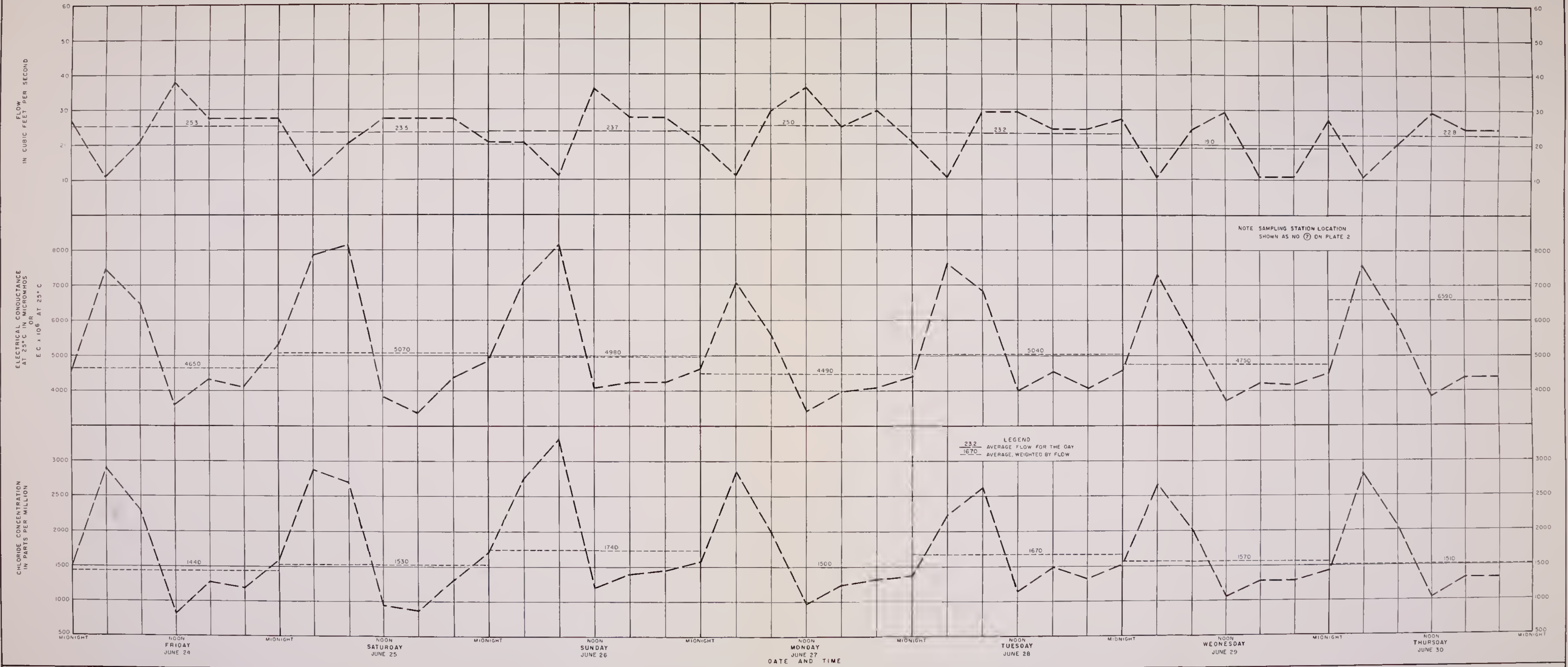
VARIATIONS IN CHLORIDE CONCENTRATION, ELECTRICAL CONDUCTIVITY, AND FLOW FOR PERIOD JUNE 24 THROUGH JUNE 30, 1955
NORTH OUTFALL SEWER AT MANHOLE NO. I, LOS ANGELES CITY SEWERAGE SYSTEM

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT 1961



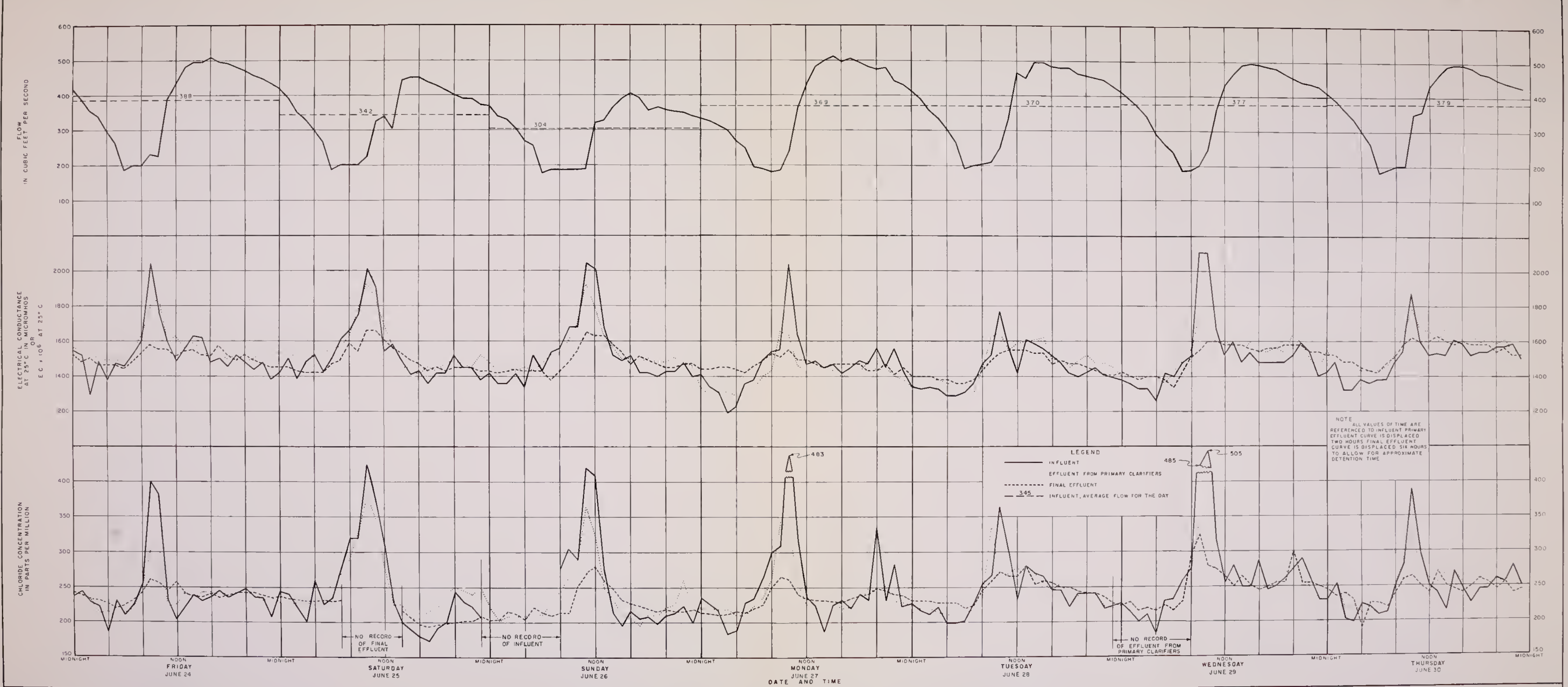
VARIATIONS IN CHLORIDE CONCENTRATION, ELECTRICAL CONDUCTIVITY, AND FLOW FOR PERIOD JUNE 24 THROUGH JUNE 30, 1955
CENTRAL OUTFALL SEWER NEAR FLORENCE AVENUE AND ASH AVENUE, LOS ANGELES CITY SEWERAGE SYSTEM

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT 1961



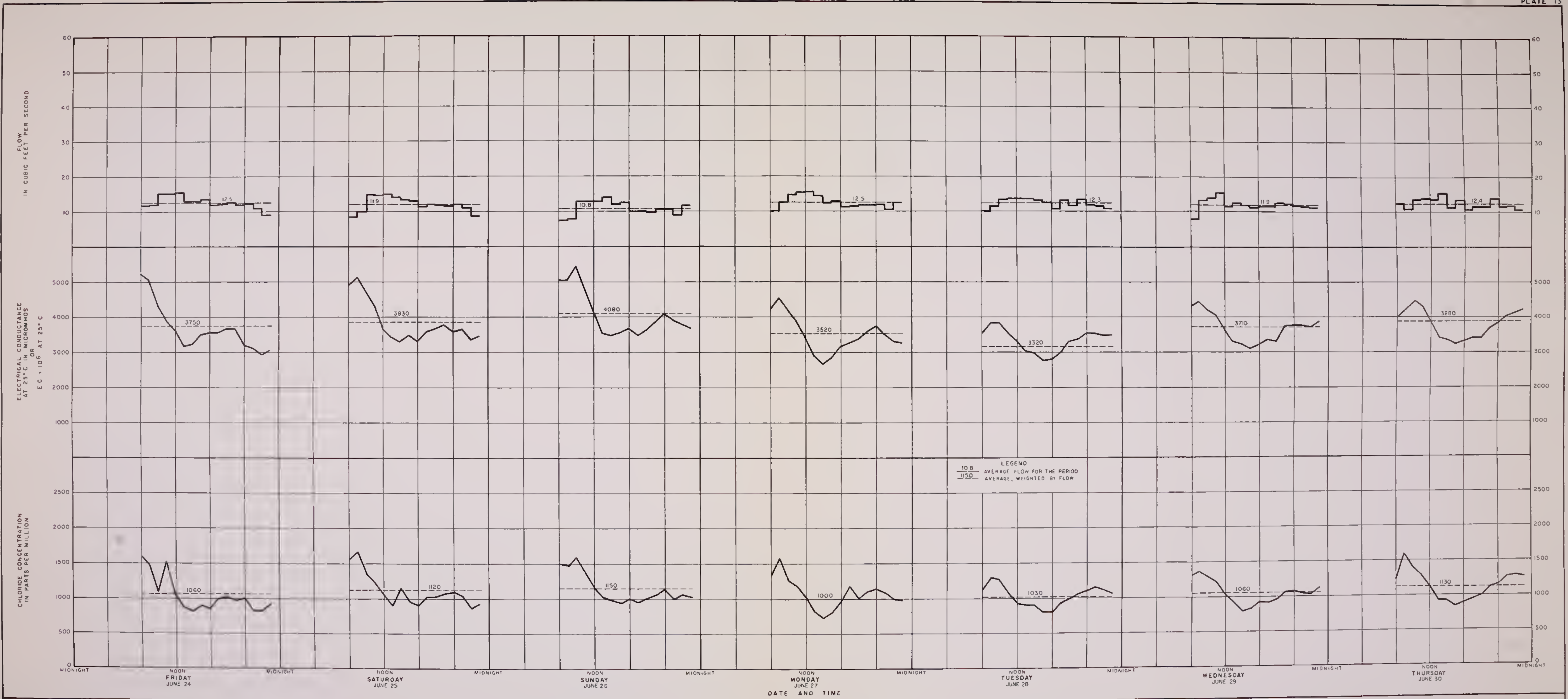
VARIATIONS IN CHLORIDE CONCENTRATION, ELECTRICAL CONDUCTIVITY, AND FLOW FOR PERIOD JUNE 24 THROUGH JUNE 30, 1955
VENICE PUMPING PLANT INFLUENT, LOS ANGELES CITY SEWERAGE SYSTEM

PLATE 12

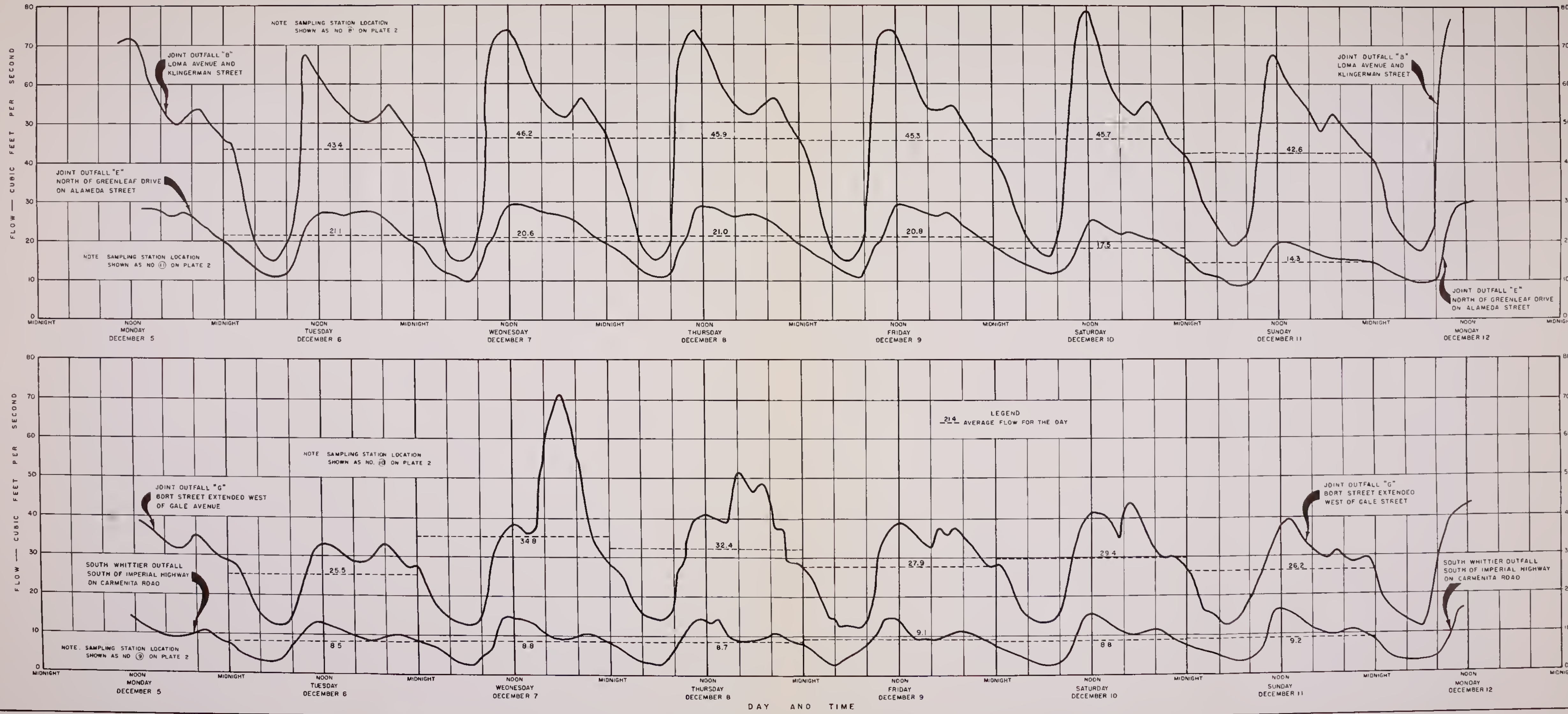


VARIATIONS IN CHLORIDE CONCENTRATION, ELECTRICAL CONDUCTIVITY, AND FLOW FOR PERIOD JUNE 24 THROUGH JUNE 30, 1955
HYPERION SEWAGE TREATMENT PLANT, LOS ANGELES CITY SEWERAGE SYSTEM

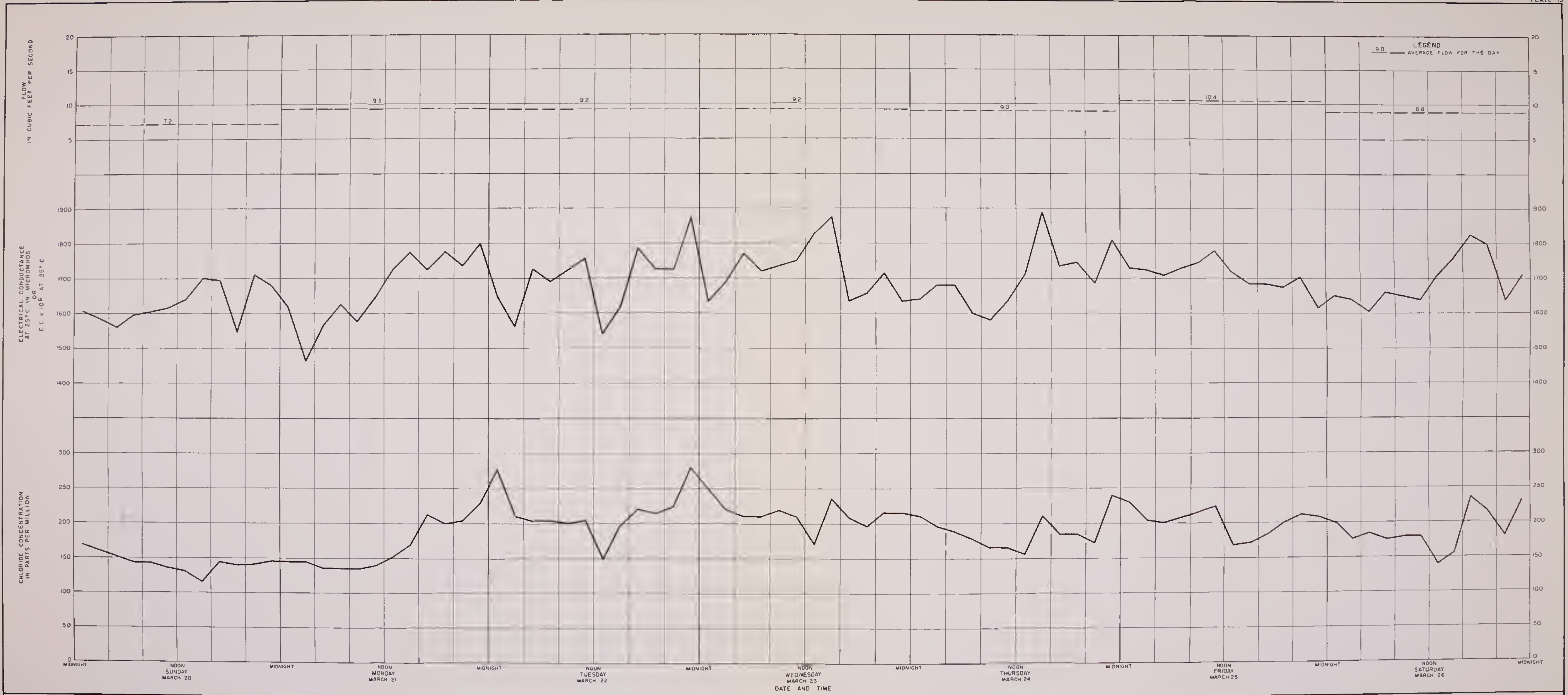
DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT 1961



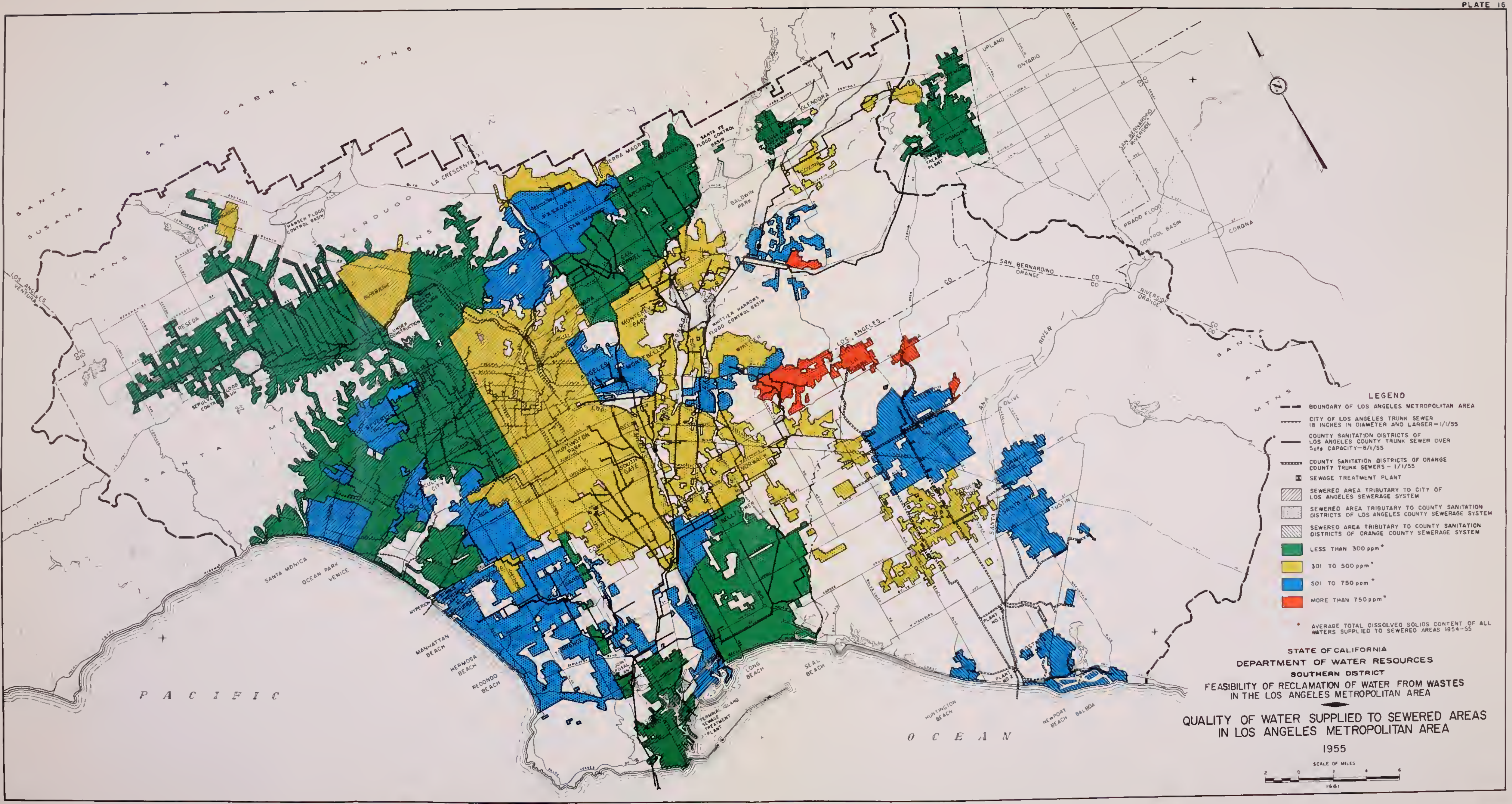
VARIATIONS IN CHLORIDE CONCENTRATION, ELECTRICAL CONDUCTIVITY, AND FLOW FOR PERIOD JUNE 24 THROUGH JUNE 30, 1955
TERMINAL ISLAND TREATMENT PLANT EFFLUENT, LOS ANGELES CITY SEWERAGE SYSTEM

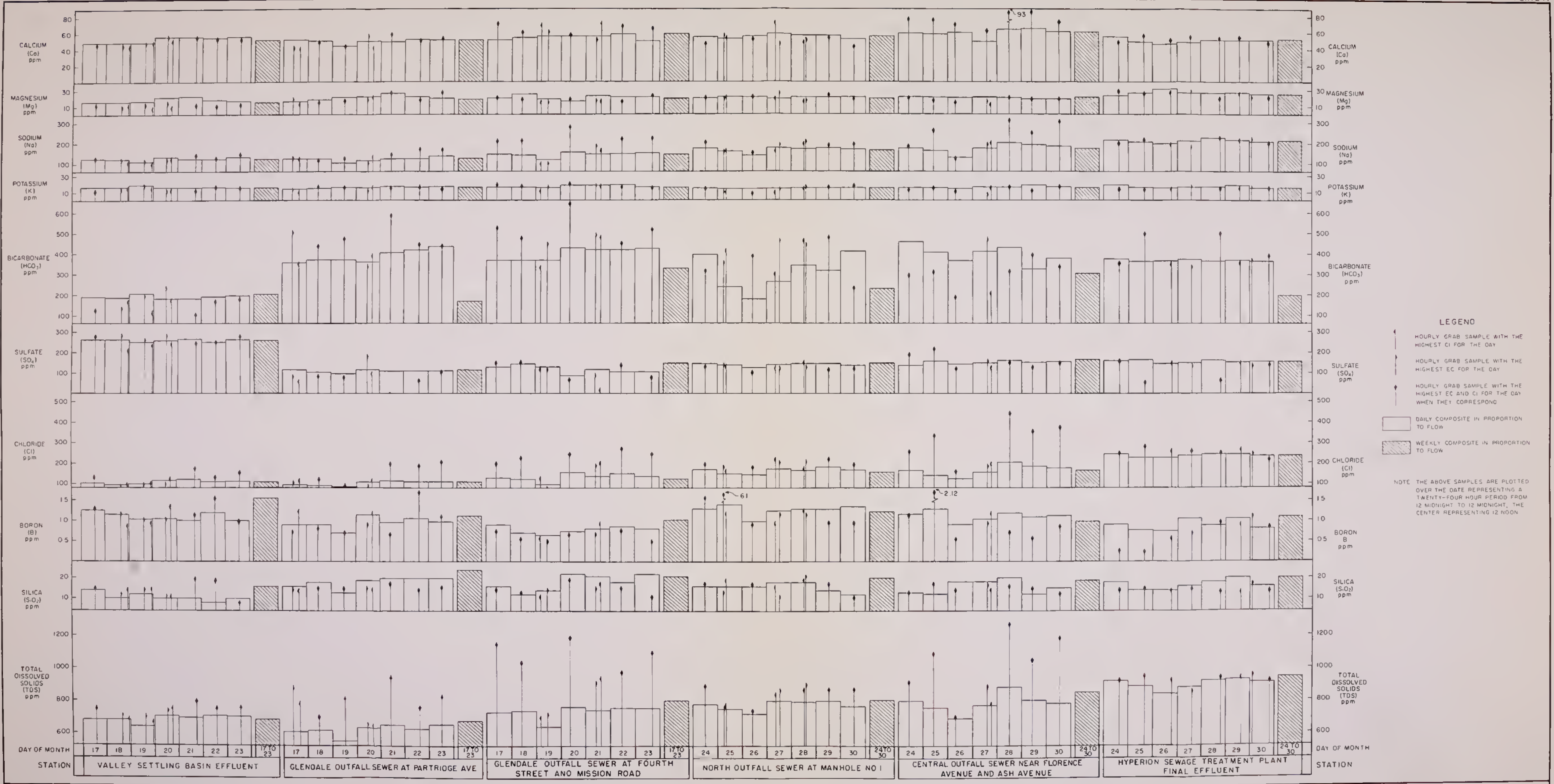


HYDROGRAPH OF SEWAGE FLOW FROM DECEMBER 5,1955 TO DECEMBER 12,1955 — COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY



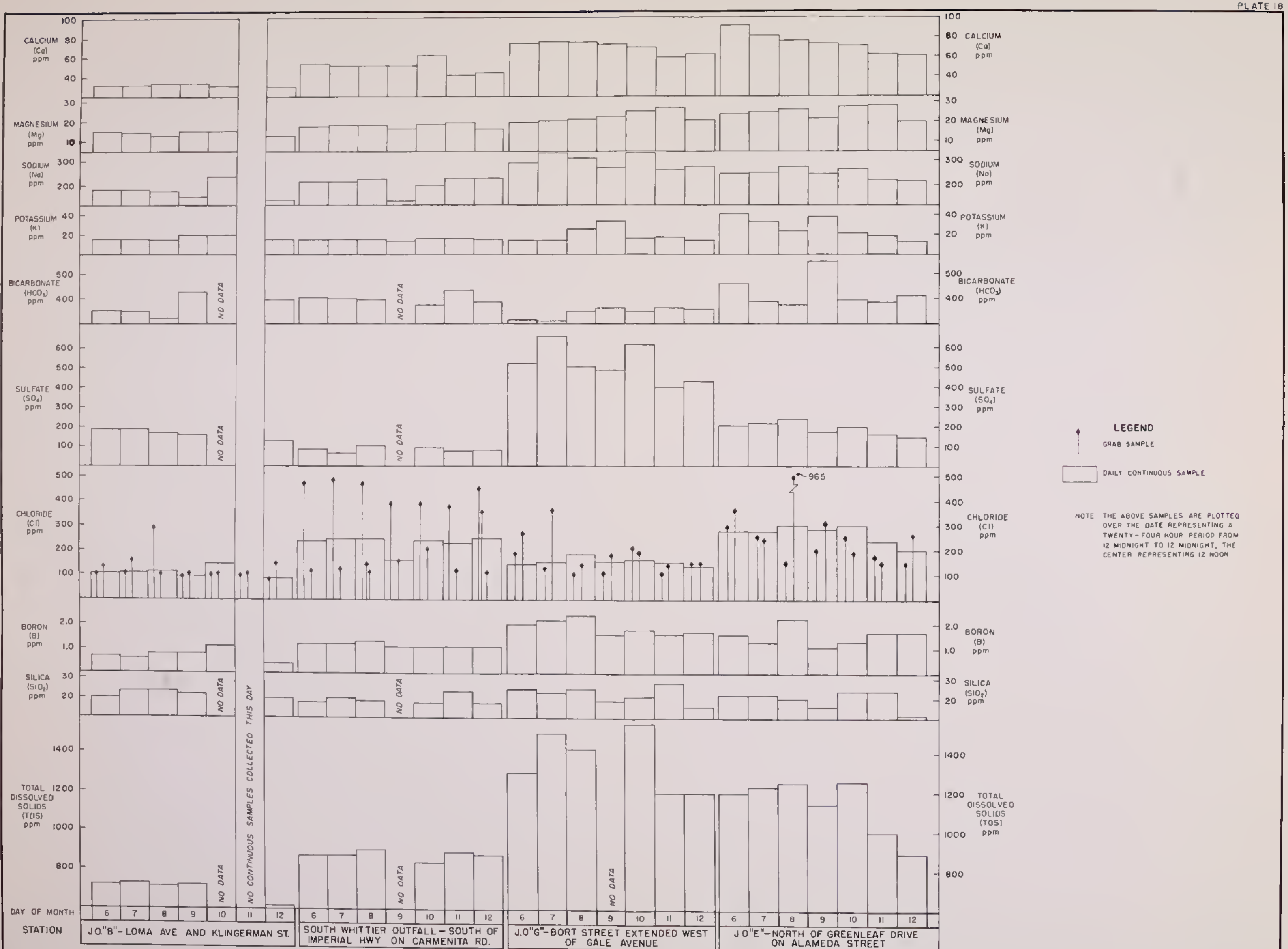
VARIATIONS IN CHLORIDE CONCENTRATION, ELECTRICAL CONDUCTIVITY, AND FLOW FOR PERIOD MARCH 20 THROUGH MARCH 26, 1955
PLANT NO.1 EFFLUENT, COUNTY SANITATION DISTRICTS OF ORANGE COUNTY


LEGEND
BOUNDARY OF LOS ANGELES METROPOLITAN AREA
CITY OF LOS ANGELES TRUNK SEWER 18 INCHES IN DIAMETER AND LARGER—1/1/55
COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY TRUNK SEWER OVER 5cfs CAPACITY—8/1/55
COUNTY SANITATION DISTRICTS OF ORANGE COUNTY TRUNK SEWERS — 1/1/55
SEWAGE TREATMENT PLANT
SEWERED AREA TRIBUTARY TO CITY OF LOS ANGELES SEWERAGE SYSTEM
SEWERED AREA TRIBUTARY TO COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY SEWERAGE SYSTEM
SEWERED AREA TRIBUTARY TO COUNTY SANITATION DISTRICTS OF ORANGE COUNTY SEWERAGE SYSTEM
LESS THAN 300 ppm*
301 TO 500 ppm*
501 TO 750 ppm*
MORE THAN 750 ppm*
* AVERAGE TOTAL DISSOLVED SOLIDS CONTENT OF ALL WATERS SUPPLIED TO SEWERED AREAS 1954-55
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT
FEASIBILITY OF RECLAMATION OF WATER FROM WASTES IN THE LOS ANGELES METROPOLITAN AREA
QUALITY OF WATER SUPPLIED TO SEWERED AREAS IN LOS ANGELES METROPOLITAN AREA
1955
SCALE OF MILES
2 0 2 4 6
1961
PACIFIC
OCEAN
SANTA MONICA
OCEAN PARK
VENICE
MANHATTAN BEACH
HERMOSA BEACH
REDONDO BEACH
LONG BEACH
SEAL BEACH
HUNTINGTON BEACH
NEWPORT BEACH
BALBOA
SANTA SUSANA MTNS
SAN GABRIEL MTNS
VERDUGO MTNS
SANTA MONICA MTNS
SANTA ANA MTNS
LA CRESCENTA
SIERRA MADRE
PASADENA
BURBANK
GLENDORA
COVINA
BALDWIN PARK
POMONA
UPLAND
ONTARIO
CORONA
RESEDA
MONTEBELLO
MONTEREY PARK
HUNTINGTON PARK
SOUTH GATE
COMPTON
BELLFLOWER
CULVER CITY
TUSTIN
SANTA ANA
WHITTIER
LOS ANGELES
SAN BERNARDINO CO
ORANGE CO
RIVERSIDE CO
LOS ANGELES CO
VENTURA CO
HANSEN FLOOD CONTROL BASIN
SEPULVEDA FLOOD CONTROL BASIN
SANTA FE FLOOD CONTROL BASIN
WHITTIER NARROWS FLOOD CONTROL BASIN
PRADO FLOOD CONTROL BASIN
UNDER CONSTRUCTION
HYPERION
TERMINAL ISLAND SEWAGE TREATMENT PLANT
PLANT NO. 1
PLANT NO. 2



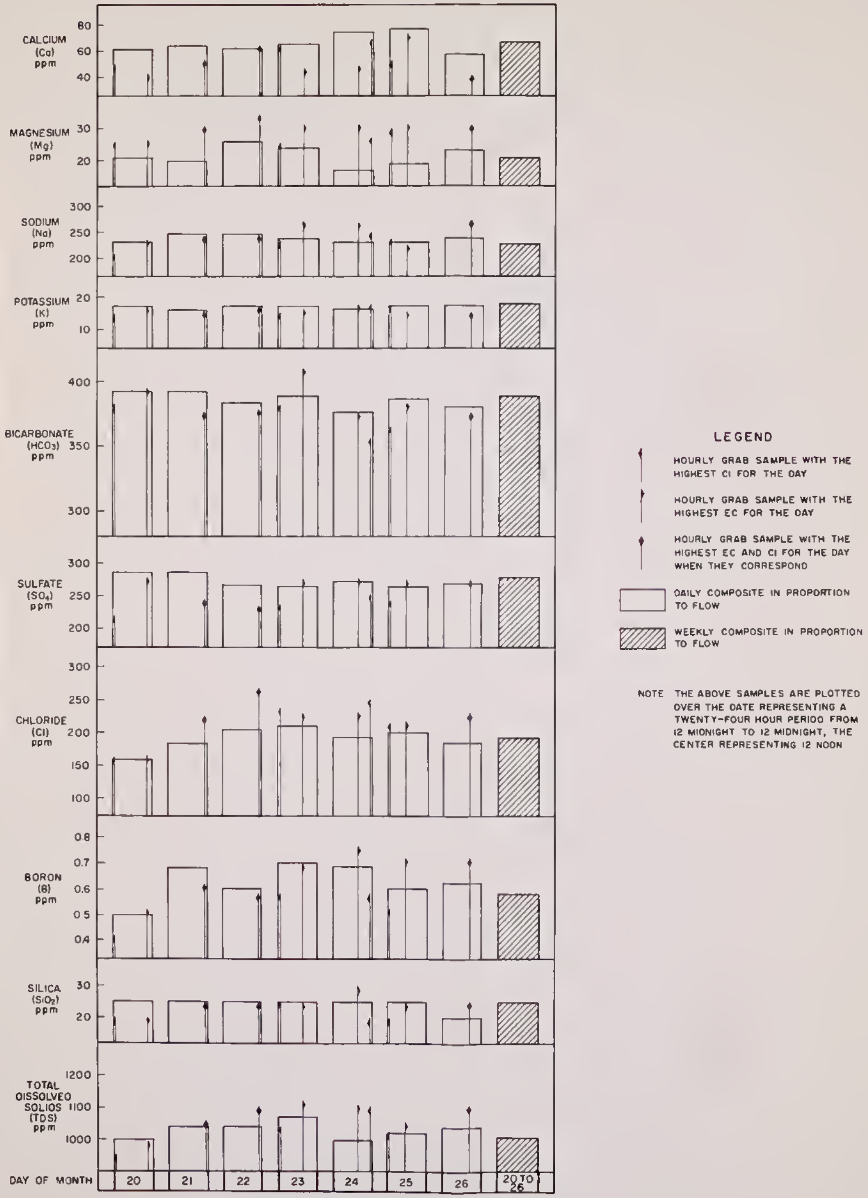
MINERAL ANALYSES OF SEWAGE SAMPLES FROM SELECTED STATIONS, CITY OF LOS ANGELES SYSTEM – JUNE 1955

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT 1961

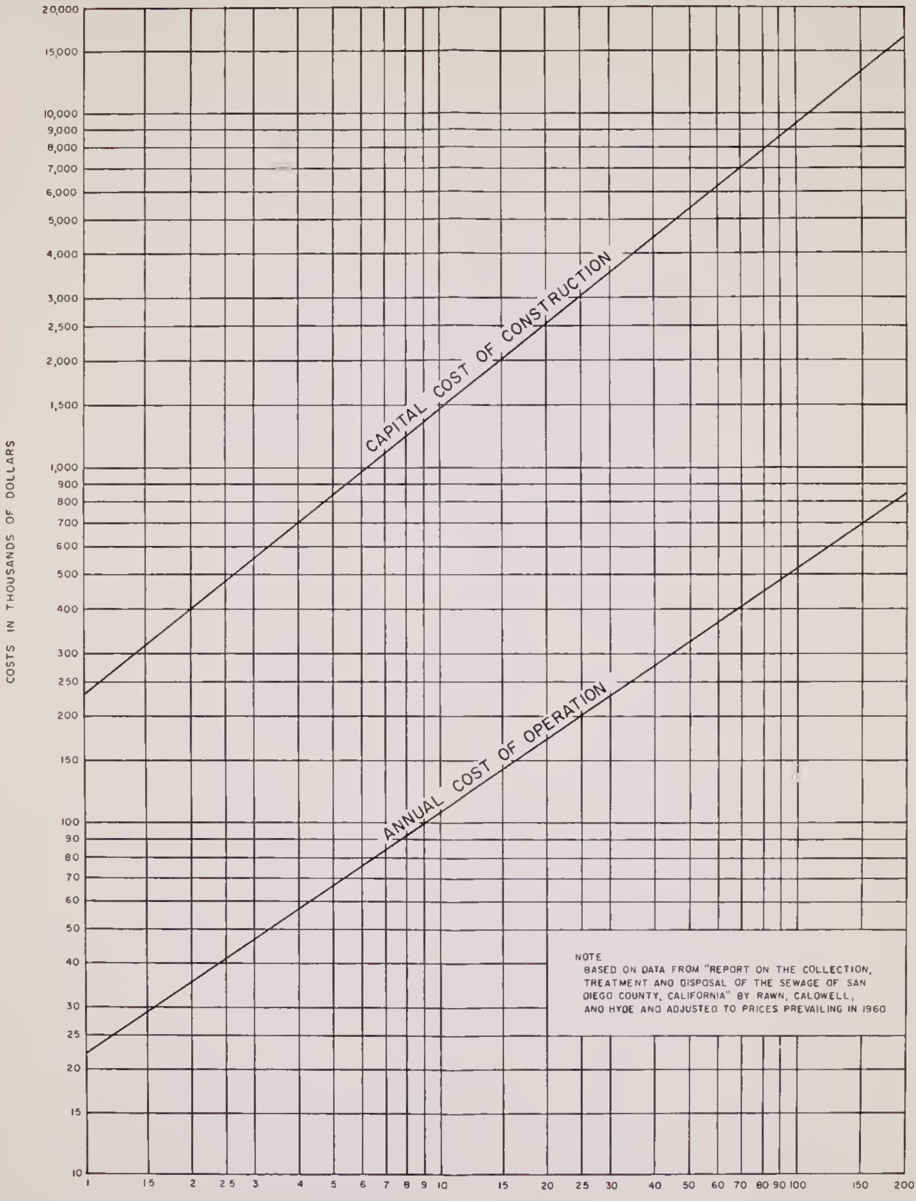


MINERAL ANALYSES OF SEWAGE SAMPLES FROM SELECTED STATIONS, COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY-DECEMBER 1955

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT 1961



MINERAL ANALYSES OF SAMPLES OF EFFLUENT FROM PLANT NO. I
COUNTY SANITATION DISTRICTS OF ORANGE COUNTY-MARCH 1955

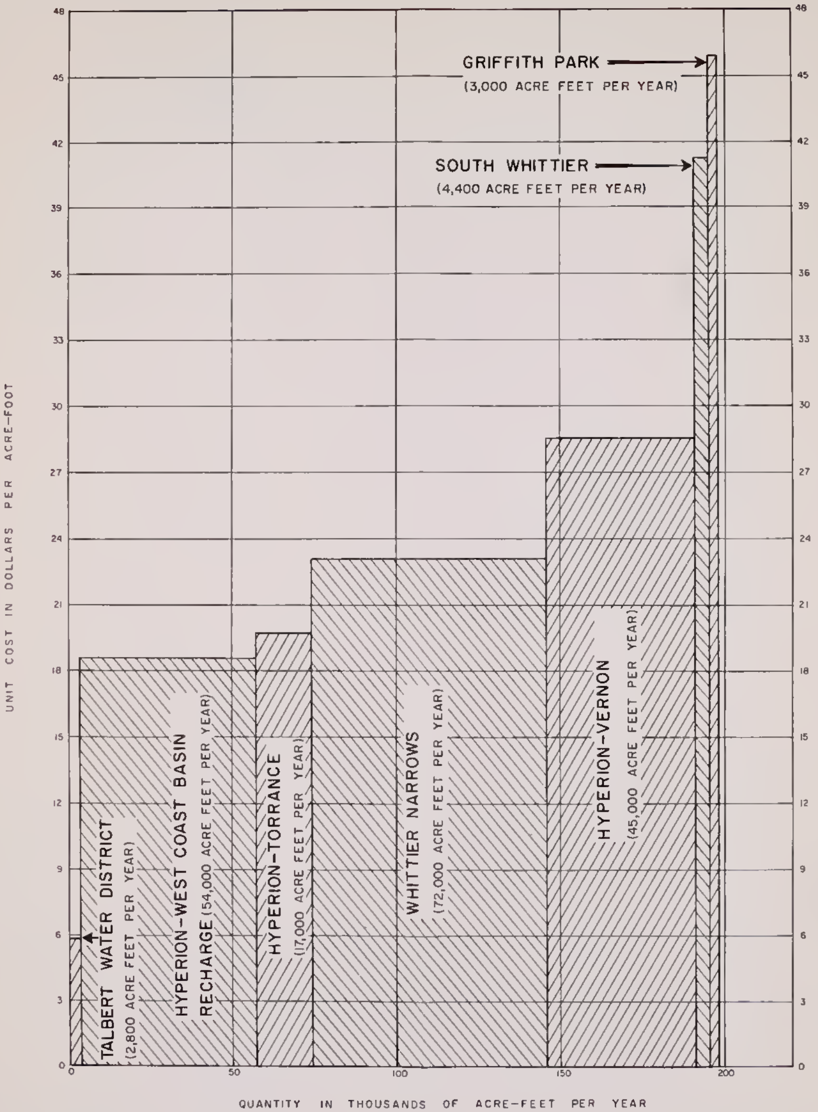


ESTIMATED COSTS OF WATER RECLAMATION PLANTS

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT

FEASIBILITY OF RECLAMATION OF WATER FROM WASTES IN THE LOS ANGELES METROPOLITAN AREA

LOCATION OF POTENTIAL WATER RECLAMATION PLANTS, CONVEYANCE SYSTEMS, AND SERVICE AREAS



COST OF RECLAIMED WATER FROM POTENTIAL PROJECTS IN THE LOS ANGELES METROPOLITAN AREA

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT 1961

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